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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXXI.

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1881-82.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1882.

'11, 2922, July 11

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CONTENTS OF VOL. XXXI.

	PAGE.		PAGE.
REPORT OF COUNCIL	vii	ASSOCIATE MEMBERS	xxxiii
FINANCE REPORT	ix	STUDENTS	xxxv
ACCOUNT OF SUBSCRIPTIONS	xii	SUBSCRIBING COLLIERIES	xxxix
TREASURER'S ACCOUNT	xiv	CHARTER	xli
GENERAL ACCOUNT	xvi	BYE-LAWS	xlvii
PATRONS	xvii	BAROMETER READINGS	249
HONORARY AND LIFE MEMBERS	xviii	ABSTRACTS OF FOREIGN PAPERS	*End of Vol.*
OFFICERS	xix	INDEX	"
ORIGINAL MEMBERS	xx		
ORDINARY MEMBERS	xxxiii		

GENERAL MEETINGS.

1881. PAGE.

Sept. 16.—Visit to Skelton Park and Lumpsey Mines 1

Oct. 1.—Notes upon Messrs. Pernolet and Aguillon's "Report upon the Working and Regulation of Fiery Mines in England," by Mr. A. L. Steavenson... 5

Discussed 27

Nov. 19.—"Description of a Method of Surveying with the Loose Needle among Rails and other Ferruginous Substances," by Mr. T. E. Candler ... 33

Discussion of Mr. T. J. Bewick's Paper, "On Diamond Rock Boring" 40

Dec. 17.—Intimation of Alteration with respect to the holding of General Meetings 49

Paper by Mr. Charles Parkin, "On Jet Mining" 51

Paper by Professor G. A. Lebour, "On the Present State of our Knowledge of Underground Temperature" 59

Discussed 71

1882.

Feb. 11.—Intimation of Arrangements made for the Publication of Abstracts from Foreign Papers 75

Paper by Mr. W. J. Bird, "On the Comparative Efficiency of Non-conducting Coverings for Steam Pipes" 77

Discussed 83

PAGE

Paper by Professor J. H. Merivale. "Abstract of an Analysis, by Dr. Chance, of Fire-damp Explosions in the Anthracite Coal Mines of Pennsylvania" 87
Discussed 90
Paper by Mr. T. J. Bowlker, "An Account of a New Ventilating Fan" 93
Paper by Mr. A. L. Steavenson, "Remarks on the Points of Interest at the Skelton Park and Lumpsey Mines, on the occasion of the Visit of the Institute, September 16th, 1881"... 105
Paper by Mr. J. W. Swan, "On an Electric Safety-lamp, with Portable Secondary Battery" 117
Discussed 118
April 22.—The President's Address 123
Paper by Mr. Robert Stevenson, "On the Use of Salt for Laying Dust in Mines" 145
Discussed 147
Paper by Mr. Edwin Gilpin, "On the Gold Fields of Nova Scotia" ... 151
June 10.—Paper by Mr. E. F. Melly, "On the Anthracite Coal of South Wales" 175
Discussed 191
Paper by the Secretary, "The Fleuss Apparatus for Breathing in Noxious Gases" 197
Discussion of Professor Lebour's Paper, "On the Mineral Resources of the Country between Rothbury and Wooler" 203
Discussion of Professor Lebour's Paper, "On the Present State of our Knowledge of Underground Temperature" 204
Discussion of Mr. Charles Parkin's Paper, "On Jet Mining" 205
June 22.—Excursion to the Langley Barony Lead Mines 209
Aug. 5.—Paper by Mr. J. D. Kendall, "On the Hæmatite Deposits of Furness" 211
Discussed 237
Discussion of Mr. T. J. Bowlker's Paper, "Description of a New Ventilating Fan" 238
Paper by Mr. E. P. Rathbone, "On the Dry, or Wind, Method of Cleaning Coal" 245

Report.

THE thirtieth year of the Institute has been one of such uniform and quiet prosperity that it leaves very little material for the Council to comment upon.

There are no shortcomings of income to gloze over, no great exceptional occurrences to explain, but simply a progress to report, and that too not of an exceptional or intermittent character, but one of a permanent and solid nature, showing that the Institute is becoming more and more secured against the fluctuations of the funds derived from subscriptions.

There is no doubt that the Institute has felt considerably the very great depression that has existed in the coal trade during the last few years, and that its progress has not been equal to that of some former years; but it is hoped that its present indication of increased prosperity may prove the forerunner of increased activity in mining generally, and foreshadow more rapid and substantial successes in the future, similar to those which caused the Institute to move onwards with leaps and bounds, and more than double its members a few years ago.

There have been many valuable additions to the Library, and exchanges have been effected with a great number of Foreign Societies to such an extent that probably few Libraries out of London are in possession of such valuable information respecting the progress of Mining Science in all countries, and this has enabled the Council to publish extracts and translations from such foreign papers as seemed to deserve particular attention, which will very materially add to the interest of the Transactions. In this the Council has been assisted by Professor Lebour, who has devoted much time and attention to this department.

The papers read before the Institute have been exceedingly interesting. The difficulty, not to say the impossibility, of gentlemen with but an imperfect knowledge of our language being able to study sufficiently in a few weeks so complicated a matter as the extraction of coal, so as to be able to write a report that should not contain many inaccuracies, has been fully demonstrated in a very able review by Mr. A. L. Steavenson of the Report of Messrs. Pernolet and Aguillon.

Underground temperature has received special attention from Professor Lebour, and that gentleman has contributed a very able report as to our present information on that important subject.

Professor Merivale has contributed a paper tabulating the explosions that have taken place in the Anthracite Coal Mines of Pennsylvania.

Among the Geological and Mining papers is one contributed by Mr. Charles Parkin "On Jet Mining," which contains most valuable and interesting information on a subject that had not previously been treated of in the Transactions.

Mr. Gilpin has contributed a very valuable paper "On the Gold Fields of Nova Scotia," and Mr. Melly one "On the Anthracite Coal of South Wales;" both of which add considerably to the value of the Transactions as works of reference.

Mr. Kendall has also written another of his carefully prepared and beautifully illustrated Geological papers "On the Hæmatite Deposits of Furness."

The more mechanical portion of the miners' profession has been treated by Mr. T. E. Candler in a paper "On a Method of Surveying with the Loose Needle among Rails and other Ferruginous Substances;" by Mr. Bird in a paper "On Non-conducting Coverings for Steam Pipes;" and by Mr. Bowlker who has contributed a description of an ingenious adaptation of the Guibal Fan, whereby he considers the efficiency of the original has been attained, whilst its size has been considerably reduced.

The safety of mines has not been overlooked, and a very excellent suggestion of Mr. Robert Stevenson's to use salt as a means of keeping down and rendering harmless the dust in mines, gave rise to an interesting and instructive discussion. The Secretary also added a description of the Fleuss apparatus, which, in the hands of Mr. Corbett and his able assistants rendered such valuable service at Seaham in enabling the men to explore the mine when filled with noxious gases.

The members also are much indebted to the President, Mr. G. B. Forster, for his very excellent Address, which contains a general summary of all the modern improvements in mining to the present time, and much other valuable information.

There has been no excursion to distant places this year, but Mr. Bewick kindly invited the members to inspect the Langley Barony Lead Mines, where the whole process of extracting lead and rendering it fit for sale was inspected by about 40 gentlemen, and a most interesting and enjoyable day was spent.

The members have been most courteously invited by the American Institute of Mining Engineers to visit the mining regions about Colorado; but, owing to the short time allowed for preparation, only a few gentlemen have been able to accept the invitation.

Finance Report.

THE Finance Committee have to report that the Finances of the Institute are in a satisfactory condition.

The highest income ever realised previous to the present year was in 1876–1877, when it stood at £2,168 16s. 4d.

It now stands at £2,176 9s. 10d., and, therefore, financially this has been the most successful year of the Institute.

The income for the past year shows an increase over that of the preceding year of £183 8s. 10d.

This increase is composed of the following items :—£107 4s., the amount of a third half-yearly dividend, which has been acquired through the Institute and Coal Trade Chambers Company, Limited, paying their dividends half-yearly instead of yearly, and which is, of course, an exceptional payment which will not occur again. There has also been a new source of income derived from the investment of £1,000 with the River Tyne Commissioners, and as only six months' interest has been received this year, amounting to £19 11s. 8d., this amount will be doubled in future. The amount derived from the sale of Transactions is £85 9s. 2d. in excess of last year, and there has also been an increase of £5 12s. in sundry matters connected with the letting of rooms. From these additions to the income, however, a diminution of £34 8s. in members' subscriptions has to be deducted, making the net increase £183 8s. 10d. as stated.

There has been a falling off of 41 members, which may be considered due to two causes; firstly, a depression of trade, and, secondly, the rigorous carrying out of the instructions of the Council to strike off the List of Members all whose arrears have exceeded a certain point defined by the Rules. This step has also reduced the amount of arrears from £569 2s. to £493 10s., being a decrease of £75 12s. A further decrease in the number of members will no doubt be shown next year, since the minute of the Council was passed after the present list of members was made up, but this does not in any way affect the position of the Institute, as those members on the list who do not pay are obviously a source of weakness rather than of strength.

The expenditure, although more than that of last year, has been £483 16s. 3d. less than the income.

The increase in the expenditure is owing to the payment of £275 10s. 2d. more for the printing of the Transactions than was paid in the preceding year, due to the publication of the Report on Ventilators, and to an increased number of illustrations.

The result of the year's work shows that there has been invested a sum of £1,000, and that there is in the bank, after deducting the balance due to the Treasurer, £502 19s. 7d. The bank balance at the commencement of the year was £1,019 3s. 4d. (after deducting the balance due to the Treasurer of £10 10s. 6d.), thus showing a net increase to the funds of the Institute of £483 16s. 3d.

WM. COCHRANE.

G. B. FORSTER.

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THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

DR. THE TREASURER IN ACCOUNT

		£	s.	d.
To 604	Original Members, as per List 1881-82.			
10	of which are Life Members.			
594	@ £2 2s.	1,247	8	0
To 22	Ordinary Members, as per List 1881-82.			
1	of which is a Life Member.			
21	1 @ £2 2s., 20 at £3 3s.	65	2	0
To 76	Associate Members, as per List 1881-82.			
1	of which is a Life Member.			
75	@ £2 2s.	157	10	0
To 123	Students, as per List 1881-82.			
1	Having paid as an Associate	2	2	0
122	@ £1 1s.	128	2	0
To 13	Subscribing Collieries	65	2	0
To 4	New Ordinary Members @ £3 3s.	12	12	0
To 11	New Associate Members.			
1	Having paid as a Life Member	20	0	0
10	@ £2 2s.	21	0	0
To 9	New Students @ £1 1s.	9	9	0
		1,728	7	0
To	Arrears, as per last Balance Sheet £569 2 0			
	Deduct—			
	Irrecoverable Arrears not inserted in 1881-82 List (Dead, Resigned, &c.) 151 4 0	417	18	0
		£2,146	5	0

Audited and Certified.

JOHN G. BENSON & CO,

CHARTERED ACCOUNTANTS.

Newcastle upon-Tyne,
3rd August, 1882.

WITH SUBSCRIPTIONS, 1881-82. CR.

		PAID. £	s.	d.	UNPAID. £	s.	d.
By 514	Original Members paid	1,079	8	0			
By 57	Do. unpaid				119	14	0
By 6	Do. dead, unpaid				12	12	0
By 4	Do. resigned, unpaid				8	8	0
By 6	Do. gone, no address				12	12	0
By 7	Do. struck off				14	14	0
594							
By 18	Ordinary Members paid	56	14	0			
By 1	Do.	2	2	0			
By 2	Do. unpaid				6	6	0
21							
By 64	Associate Members paid	134	8	0			
By 8	Do. unpaid				16	16	0
By 1	Do. dead, unpaid				2	2	0
By 2	Do. struck of				4	4	0
75							
By 97	Students paid	101	17	0			
By 13	Do. unpaid				13	13	0
By 1	Do. dead				1	1	0
By 5	Do. gone, no address				5	5	0
By 3	Do. struck off				3	3	0
By 3	Do. resigned				3	3	0
122							
By 1	Do. paid as an Associate	2	2	0			
By 13	Subscribing Collieries paid	65	2	0			
By 3	New Ordinary Members paid	9	9	0			
By 1	Do. unpaid				3	3	0
4							
By 8	New Associate Members paid	16	16	0			
By 2	Do. unpaid				4	4	0
10							
By 1	Do. Life Member	20	0	0			
By 5	New Students paid	5	5	0			
By 4	Do. unpaid...				4	4	0
9							
		1,493	3	0	235	4	0
By Members' Arrears		141	15	0	236	5	0
By Students' do.		17	17	0	22	1	0
		1,652	15	0	493	10	0
					1,652	15	0
					£2,146	5	0

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

DR. *For the Year ending*

				£	s.	d.
To Balance at Bankers ...				1,029	13	10
To Dividend of 8 per cent. on 134 Shares of £20 each = £2,680 ...				321	12	0
To Rent of College Class Rooms, less Borough Rates ...				50	17	6
To Literary and Philosophical Society, Balance of Librarian's Salary ...				3	10	0
To Interest on Investment with River Tyne Commissioners ...				19	11	8
				1,425	5	0
To Subscriptions for 1881-82 from 514 Original Members ...	£1,079	8	0			
To Do. do. 18 Ordinary Members ...	56	14	0			
To Do. do. 1 do. ...	2	2	0			
To Do. do. 64 Associate Members ...	134	8	0			
To Do. do. 97 Students ...	101	17	0			
To Do. do. 1 do. paid as Member ...	2	2	0			
To Do. do. 3 New Ordinary Members ...	9	9	0			
To Do. do. 8 New Associate Members ...	16	16	0			
To Do. do. 1 New Life Member... ...	20	0	0			
To Do. do. 5 New Students ...	5	5	0			
To Subscribing Collieries:—	1,428	1	0			
Ashington ...	£2	2	0			
Haswell ...	4	4	0			
Hetton ...	10	10	0			
Lambton ...	10	10	0			
North Hetton ...	10	10	0			
Londonderry ...	6	6	0			
Ryhope ...	4	4	0			
Seghill ...	2	2	0			
South Hetton ...	4	4	0			
Stella ...	2	2	0			
Throckley ...	2	2	0			
Wearmouth ...	4	4	0			
Whitworth ...	2	2	0			
	65	2	0			
	1,493	3	0			
To Members' Arrears ...	141	15	0			
To Students' do. ...	17	17	0			
	159	12	0			
				1,652	15	0
To Sale of Publications, per A. Reid ...	130	7	6			
Less 10 per cent. Commission ...	13	0	8			
	117	6	10			
To Sale of Publications, per Secretary ...	10	16	10			
				128	3	8
To Balance due Treasurer ...				34	16	5
				£3,241	0	1

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

August, 1882. Cr.

	£	s.	d.	£	s.	d
By Balance due Treasurer				10	10	6
By Paid A. Reid, Publishing Account	546	15	2			
By Do. Covers for Parts and Stitching	30	16	0			
By Do. Binding and Sewing Volumes	35	8	2			
By Do. Postage	50	11	3			
By Do. Stationery and Circulars	76	8	6			
By Do. Library	69	17	8			
By Do. Borings	45	8	9			
				855	5	6
By other Printing and Stationery				1	1	7
By Secretary's Incidental Expenses and Postages				164	9	9
By Sundry Accounts				35	4	5
By Travelling Expenses and Expense of Meeting at Cleveland				10	7	5
By Secretary's Salary				300	0	0
By Assistant's Do.				75	0	0
By Reporter's Do.				12	12	0
By Payments on Account of Furnishing				12	10	0
By Rent				73	10	2
By Rates and Taxes				13	8	7
By Fire Insurance				9	0	6
By Water, Coals, and Gas				15	4	2
By Subscription to the Natural History Society				20	0	0
By Books for Library in addition to amount paid A. Reid...				66	9	6
By Awards for Papers				28	10	0
				1,703	4	1
By Invested with River Tyne Commissioners	1,000	0	0			
By Balance at Bankers...	537	16	0			
				1,537	16	0
				£3,241	0	1

Audited and Certified,

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Newcastle-upon-Tyne,
3rd August, 1882.

GENERAL STATEMENT, AUGUST, 1882.

Dr.

Liabilities.	£	s.	d.
None	"	"	"
Capital	9,864	19	7
	£9,864	19	7

Audited and Certified
(Share Certificates and Bond produced),
JOHN G. BENSON & CO.,
Chartered Accountants.

Newcastle-upon-Tyne,
3rd August, 1882.

Cr.

Assets.		£	s.	d.
Balance of Account at Bankers	£537 16 0			
Less Balance due Treasurer	34 16 5			
		502	19	7
134 Shares of £20 each in the Institute and Coal Trade Chambers Company (Limited)		2,680	0	0
Invested with River Tyne Commissioners		1,000	0	0
Arrears of Subscriptions		493	10	0
Value of 248 Bound Volumes of Transactions, @ 11s. 6d.		142	12	0
Value of 3,876 Sewn Copies of Transactions, @ 9s. ...		1,744	4	0
Value of sundry Sheets and Plates belonging to Vol. XXXI., unfinished at this date		100	0	0
Value of 37 Copies of Mr. T. F. Brown's Map of the South Wales Coal-field, @ 5s.		9	5	0
Value of 398 Copies of General Index, @ 3s.		59	14	0
Value of 768 Copies of Fossil Illustrations, @ 12s. 6d. ...		480	0	0
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Value of 1,500 sheets of Borings and Sinkings		300	0	0
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Value of Furniture and Office Fittings		300	0	0
Value of Books and Maps in Library		1,500	0	0
		£9,864	19	7

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JAMES WILLIS, Esq., 14, Portland Terrace, Newcastle-on-Tyne.

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- SIR W. G. ARMSTRONG, C.B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne. (Past Presidents.)
- E. F. BOYD, Esq., Moor House, Fence Houses. (Past Presidents.)
- SIR GEORGE ELLIOT, Bart., M.P., Houghton Hall, Fence Houses. (Past Presidents.)
- G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby. (Past Presidents.)
- LINDSAY WOOD, Esq., Southill, Chester-le-Street. (Past Presidents.)
- J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne: Retiring Vice-President.

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

List of Members.

AUGUST, 1882.

Original Members.

Marked (*) are Life Members.

		ELECTED.
1	ADAMS, G. F., Guild Hall Chambers, Cardiff	Dec. 6, 1873
2	ADAMS, W., Cambridge House, Park Place, Cardiff	1854
3	ADAMSON, DANIEL, Engineering Works, Dukinfield, near Manchester	Aug. 7, 1875
4	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
5	ALLISON, T., Belmont Mines, Guisbro'	Feb. 1, 1868
6	ANDERSON, C. W., Cleadon House, Harrogate	Aug. 21, 1852
7	ANDERSON, WILLIAM, Rainton Colliery, Fence Houses	Aug. 21, 1852
8	ANDREWS, HUGH, Felton Park, Felton, Northumberland	Oct. 5, 1872
9	APPLEBY, C. E., Charing Cross Chambers, Duke St., Adelphi, London	Aug. 1, 1861
10	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
11	ARMSTRONG, SIR W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne ... ... (PAST PRESIDENT, *Member of Council*)	May 3, 1866
12	ARMSTRONG, WM., Pelaw House, Chester-le-Street (VICE-PRESIDENT)	Aug. 21, 1852
13	ARMSTRONG, W., Junior, Wingate, Co. Durham	April 7, 1867
14	ARMSTRONG, W. L., Kettlebrook Colliery, Tamworth	Mar. 3, 1864
15	ARTHUR, DAVID, M.E., Accrington, near Manchester	Aug. 4, 1877
16	ASHWORTH, JAMES, Mapperley Colliery, West Hallam, Derby ...	Feb. 5, 1876
17	ASHWORTH, JOHN, Hanover Chambers, King Street, Manchester ...	Sept. 2, 1876
18	ASQUITH, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
19	ATKINSON, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
20	ATKINSON, W. N., Shincliffe Hall, Durham	June 6, 1868
21	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
22	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
23	AYNSLEY, WM., Brynkinalt Collieries, Chirk, Ruabon	Mar. 3, 1873
24	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
25	BAILES, JOHN, Wingate Colliery, Ferryhill	Sept. 5, 1868
26	BAILES, T., 6, Collingwood Terrace, Jesmond Terrace, Newcastle ...	Oct. 7, 1858
27	BAILES, W., West Melton, Rotherham	April 7, 1877
28	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859
29	BAIN, R. DONALD, Newport, Monmouthshire	Mar. 3, 1873
30	BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield	Dec. 3, 1863
31	BANKS, THOMAS, Leigh, near Manchester	Aug. 4, 1877

		ELECTED.
32	BARCLAY, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
33	BARNES, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne ...	Oct. 7, 1871
34	BARRAT, A. J., Ruabon Coal Co., Ruabon	Sept. 11, 1875
35	BARTHOLOMEW, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
36*	BARTHOLOMEW, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
37	BASSETT, A., Tredegar Mineral Estate Office, Cardiff	1854
38	BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
39	BATES, W. J., Old Axwell, Whickham, Gateshead-on-Tyne	Mar. 3, 1873
40	BATEY, JOHN, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
41	BEANLANDS, A., M.A., North Bailey, Durham	Mar. 7, 1867
42	BEAUMONT, JAMES, M.E., Nanaimo, Vancouver's Island	Nov. 7, 1874
43	BELL, I. L., Rounton Grange, Northallerton	July 6, 1854
44	BELL, JOHN, Messrs. Bell Brothers, Middlesbro'-on-Tees	Oct. 1, 1857
45	BELL, T., Jun., Messrs. Bell Brothers, Middlesbro'-on-Tees	Mar. 7, 1867
46	BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne ..	Nov. 7, 1874
47	BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)*	Aug. 2, 1866
48	BERKLEY, C., Marley Hill Colliery, Gateshead ... (VICE-PRESIDENT)	Aug. 21, 1852
49	BEWICK, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland (VICE-PRESIDENT)	April 5, 1860
50	BIDDER, B. P., c/o C. J. Ryland, 3, Small Street, Bristol	May 2, 1867
51	BIGLAND, J., Bedford Lodge, Bishop Auckland	June 4, 1857
52	BINNS, C., Claycross, Derbyshire	July 6, 1854
53	BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ...	1856
54	BLACK, JAMES, Jun., Portobello Foundry, Sunderland	Sept. 2, 1871
55	BLACK, W., Hedworth Villa, South Shields	April 2, 1870
56	BOLAM, H. G., Little Ingestre, Stafford	Mar. 6, 1875
57	BOLTON, H. H., Newchurch Collieries, near Manchester	Dec. 5, 1868
58	BOOTH, R. L., Ashington Colliery, near Morpeth	1864
59	BOURNE, THOS. W., Broseley, Salop	Sept. 11, 1875
60	BOYD, E. F., Moor House, Fence Houses (PAST PRES., *Mem. of Council*)	Aug. 21, 1852
61	BOYD, R. F., Moor House, Fence Houses ...*(Member of Council)*	Nov. 6, 1869
62	BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne *(Mem. of Council)*	Feb. 2, 1867
63	BRADFORD, GEO., Etherley, Bishop Auckland	Oct. 11, 1873
64	BRECKON, J. R., Park Place, Sunderland	Sept. 3, 1864
65	BRETTELL, T., Mine Agent, Dudley, Worcestershire	Nov. 3, 1866
66	BROMILOW, WM., 18, Leicester Street, Southport, Lancashire ...	Sept. 2, 1876
67	BROWN, JOHN, The Hawthorns, 3, Lozell's Road, Birmingham ...	Oct. 5, 1854
68	BROWN, J. N., 56, Union Passage, New Street, Birmingham ...	1861
69	BROWN, THOS. FORSTER, Guild Hall Chambers, Cardiff	1861
70	BROWNE, B. C., M.I.C.E., No. 2, Granville Road, Jesmond, Newcastle	Oct. 1, 1870
71	BRUTON, W., 37, College Street, Rotherham, Yorkshire	Feb. 6, 1869
72	BRYHAM, WILLIAM, Rosebridge Colliery, Wigan	Aug. 1, 1861
73	BRYHAM, W., Jun., Douglas Bank Collieries, Wigan	Aug. 3, 1865
74	BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)*	1864
75*	BURNS, DAVID, C.E., Clydesdale Bank Buildings, Bank St., Carlisle...	May 5, 1877
76	BURROWS, J. S., Yew Tree House, Atherton, near Manchester ...	Oct. 11, 1873

		ELECTED.
77	CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ...	Oct. 7, 1876
78	CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne	Dec. 3, 1857
79	CHADBORN, B. T., Pinxton Collieries, Alfreton, Derbyshire	1864
80	CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield	Mar. 6, 1869
81	CHAPMAN, M., Plashetts Colliery, Northumberland	Aug. 1, 1868
82	CHEESMAN, I., Throckley Colliery, Newcastle-on-Tyne	Feb. 1, 1873
83	CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool	Feb. 5, 1876
84	CHILDE, ROWLAND, Wakefield, Yorkshire	May 15, 1862
85	CLARENCE, THOMAS, 10, Bentinck Crescent, Newcastle-on-Tyne ...	Dec. 4, 1875
86	CLARK, C. F., Garswood Coal and Iron Co., near Wigan	Aug. 2, 1866
87	CLARK, R. B., Marley Hill, near Gateshead	May 3, 1873
88	CLARK, W., M.E., The Grange, Teversall, near Mansfield	April 7, 1866
89	CLARKE, WILLIAM, Victoria Engine Works, Gateshead	Dec. 7, 1867
90	COCHRANE, B., Aldin Grange, Durham	Dec. 6, 1866
91	COCHRANE, C., The Grange, Stourbridge	June 3, 1857
92	COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle *(Member of Council)*	1859
93	COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne	April 5, 1873
94	COLE, ROBERT HEATH, Scholar Green, Stoke-upon-Trent	Feb. 5, 1876
95	COLE, W. R., Broomfield, Jesmond, Newcastle *(Member of Council)*	Oct. 1, 1857
96	COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ...	June 6, 1861
97	COOK, J., Jun., Washington Iron Works, Gateshead	May 8, 1869
98	COOKE, JOHN, 3, Cross Street, Durham	Nov. 1, 1860
99	COOKSEY, JOSEPH, West Bromwich, Staffordshire	Aug. 3, 1865
100	COOPER, P., Thornley Colliery Office, Ferryhill...	Dec. 3, 1857
101	COOPER, R. E., C.E., 1, Westminster Chambers, Victoria Street, London	Mar. 4, 1871
102	COOPER, T., Rosehill, Rotherham, Yorkshire	April 2, 1863
103	COPE, JAMES, Port Vale, Longport, Staffordshire	Oct. 5, 1872
104	CORBETT, V. W., Chilton Moor, Fence Houses *(Member of Council)*	Sept. 3, 1870
105	CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead	Dec. 4, 1875
106	COULSON, F., 10, Victoria Terrace, Durham	Aug. 1, 1868
107	COULSON, W., 32, Crossgate, Durham	Oct. 1, 1852
108	COWEN, JOS., M.P., Blaydon Burn, Newcastle-on-Tyne	Oct. 5, 1854
109	COWEY, JOHN, Wearmouth Colliery, Sunderland	Nov. 2, 1872
110	COWLISHAW, J., Thorncliffe, &c., Collieries, near Sheffield	Mar. 7, 1867
111	COX, JOHN H., 10, St. George's Square, Sunderland	Feb. 6, 1875
112*	COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ...	Feb. 1, 1873
113	COXON, S. B., 23, Great George Street, Westminster, London ...	June 5, 1856
114	CRAIG, W. Y., Palace Chambers, St. Stephen's, Westminster, London	Nov. 3, 1866
115	CRAWFORD, T., Littletown Colliery, near Durham	Aug. 21, 1852
116	CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne	Sept. 3, 1864
117	CRAWFORD, T., Jun. Littletown Colliery, near Durham	Aug. 7, 1869
118	CRAWSHAY, E., Gateshead-on-Tyne	Dec. 4, 1869
119	CRAWSHAY, G., Gateshead-on-Tyne	Dec. 4, 1869
120	CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne	Mar. 5, 1870
121	CRONE, J. R., Tow Law, *via* Darlington	Feb. 1, 1868
122	CRONE, S. C., Killingworth Colliery, Newcastle *(Member of Council)*	1853

		ELECTED.
123	CROSS, JOHN, 77, King Street, Manchester	June 5, 1869
124	CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, N. Wales	Nov. 2, 1872
125	CROUDACE, JOHN, West House, Haltwhistle	June 7, 1873
126	CROUDACE, THOMAS, Lambton Lodge, New South Wales	1862
127	DAGLISH, JOHN, Marsden, South Shields ... (VICE-PRESIDENT)	Aug. 21, 1852
128	DAGLISH, W. S., Solicitor, Newcastle-on-Tyne	July 2, 1872
129	DAKERS, J., Chilton Colliery, Ferryhill	April 11, 1874
130	DALE, DAVID, West Lodge, Darlington	Feb. 5, 1870
131	D'ANDRIMONT, T., Liége, Belgium	Sept. 3, 1870
132	DANIEL, W., Steam Plough Works, Leeds	June 4, 1870
133	DARLING, FENWICK, South Durham Colliery, Darlington	Nov. 6, 1875
134	DARLINGTON, JAMES, Black Park Colliery Co. Limited, Ruabon ...	Nov. 7, 1874
135	DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London	April 1, 1865
136	DAVEY, HENRY, C.E., Leeds	Oct. 11, 1873
137	DAVIS, DAVID, Coal Owner, Maesyffynon, Aberdare	Nov. 7, 1874
138	DAY, W. H., Eversley Garth, So. Milford	Mar. 6, 1869
139	DEES, R. R., Solicitor, Newcastle-on-Tyne	Oct. 7, 1871
140	DICKINSON, G. T., 14, Claremont Place, Newcastle-on-Tyne	July 2, 1872
141	DICKINSON, R., Coal Owner, Shotley Bridge, Co. Durham	Mar. 4, 1871
142	DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ...	Nov. 2, 1872
143	DIXON, NICH., Dudley Colliery, Dudley, Northumberland	Sept. 1, 1877
144	DIXON, R., Wire Rope Manufacturer, Teams, Gateshead	June 5, 1875
145	DODD, B., Bearpark Colliery, near Durham	May 3, 1866
146	DODDS, JOSEPH, M.P., Stockton-on-Tees	Mar. 7, 1874
147	DOUGLAS, C. P., Parliamnt Street, Consett, Co. Durham	Mar. 6, 1869
148	DOUGLAS, T., Pease's West Collieries, Darlington (VICE-PRESIDENT)	Aug. 21, 1852
149	DOVE, G., Viewfield, Stanwix, Carlisle	July 2, 1872
150	DOWDESWELL, H., Butterknowle Colliery, *via* Darlington	April 5, 1873
151	DYSON, GEORGE, Middlesborough	June 2, 1866
152	DYSON, O., Pooley Hall Colliery, near Tamworth	Mar. 2, 1872
153	EASTON, J., Nest House, Gateshead	1853
154	EDDISON, ROBERT W., Steam Plough Works, Leeds	Mar. 4, 1876
155	ELLIOT, SIR GEORGE, Bart., M.P., Houghton Hall, Fence Houses (PAST PRESIDENT, *Member of Council*)	Aug. 21, 1852
156	ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ...	Nov. 4, 1876
157	EMBLETON, T. W., The Cedars, Methley, Leeds	Sept. 6, 1855
158	EMBLETON, T. W., Jun., The Cedars, Methley, Leeds	Sept. 2, 1865
159	EMINSON, J. B., Londonderry Offices, Seaham Harbour	Mar. 2, 1872
160	EVERARD, I. B., M.E., 6, Millstone Lane, Leicester	Mar. 6, 1869
161	FARMER, A., South Durham Fitting Offices, West Hartlepool ...	Mar. 2, 1872
162	FARRAR, JAMES, Old Foundry, Barnsley	July 2, 1872
163	FAVELL, THOMAS M., 14, Saville Street, North Shields	April 5, 1873
164	FENWICK, BARNABAS, Team Colliery, Gateshead	Aug. 2, 1866

ELECTED.

165 FENWICK, GEORGE, Banker, Newcastle-on-Tyne ... ... Sept. 2, 1871
166 FENWICK, THOMAS, Victoria Terrace, Lanchester, Co. Durham ... April 5, 1873
167 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
168 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
169 FISHER, R. C., 5, Picton Place, Swansea ... ... July 2, 1872
170 FLETCHER, GEO., Castle Eden Colliery, Co. Durham ... ... Aug. 1, 1874
171 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
172 FLETCHER, JAS., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
173 FLETCHER, J., Kelton House, Dumfries... ... ... July 2, 1872
174 FLETCHER, W., Lansdowne House, Didsbury, Manchester ... ... Feb. 4, 1871
175 FOGGIN, WM., North Biddick Coll., Washington Station, Co. Durham Mar. 6, 1875
176 FORREST, J., Assoc. Inst. C.E., Witley Coll., Halesowen, Birmingham Mar. 5, 1870
177 FORSTER, G. B., M.A., Backworth House, near Newcastle-upon-Tyne (PRESIDENT) Nov. 5, 1852
178 FORSTER, J. R., Water Company's Office, Newcastle-on-Tyne ... July 2, 1872
179 FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham ... Aug. 1, 1868
180 FORSTER, RICHARD, 51, Quayside, Newcastle ... ... Oct. 5, 1872
181 FORSTER, R., South Hetton, Fence Houses *(Member of Council)* Sept. 5, 1868
182 FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds ... ... Mar. 7, 1874
183 FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire Sept. 1, 1877
184 FRANCE, W., Lofthouse Mines, Saltburn-by-the-Sea ... ... April 6, 1867
185 FRANKS, GEORGE, Victoria Garesfield, Lintz Green ... ... Feb. 6, 1875

186 GALLOWAY, R. L., Ryton-on-Tyne ... ... Dec. 6, 1873
187 GALLOWAY, T. LINDSAY, M.A., 28, Enoch Square, Glasgow ... ... Sept. 2, 1876
188 GERRARD, JOHN, Westgate, Wakefield ... ... Mar. 5, 1870
189 GILLETT, F. C., Midland Road, Derby ... ... July 4, 1861
190 GILMOUR, D., Portland Colliery, Kilmarnock ... ... Feb. 3, 1872
191 GILPIN, EDWIN, 75, Birmingham Street, Halifax, Nova Scotia ... April 5, 1873
192 GILROY, G., Ince Hall Colliery, Wigan, Lancashire ... ... Aug. 7, 1856
193 GILROY, S. B., Mining Engineer, Cheatham Hill, Manchester ... Sept. 5, 1868
194 GJERS, JOHN, Southfield Villas, Middlesbro' ... ... June 7, 1873
195 GODDARD, F. R., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
196 GOOCH, G. H., Lintz Colliery, Burnopfield, Gateshead... ... ... Oct. 3, 1856
197 GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C. ... ... Nov. 6, 1875
198 GRACE, E. N., Dhadka, Assensole, Bengal, India ... ... Feb. 1, 1868
199 GRANT, J. H., District Engineer, Beerbhoon, Bengal, India ... ... Sept. 4, 1869
200 GREAVES, J. O., M.E., St. John's, Wakefield ... ... Aug. 7, 1862
201 GREEN, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon. Dec. 3, 1870
202 GREEN, W., JUN., Thornelly House, Lintz Green *(Member of Council)* Feb. 4 1853
203 GREENER, JOHN, General Manager, Vale Coll., Pictou, Nova Scotia ... Feb. 6, 1875
204 GREENWELL, G. C., Elm Tree Lodge, Driffield, Derby (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
205 GREENWELL, G. C., JUN., Poynton, near Stockport ... ... Mar. 6, 1869
206 GREIG, D., Leeds ... ... Aug. 2, 1866

		ELECTED.
207	GREY, C. G., 55, Parliament Street, London	May 4, 1872
208	GRIEVES, D., Brancepeth Colliery, Willington, County Durham ...	Nov. 7, 1874
209	GRIFFITH, N. R., Wrexham	1866
210	GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ...	Sept. 5, 1868
211	HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ...	Mar. 4, 1876
212	HAGGIE, P., Gateshead	1854
213*	HAGUE, ERNEST, Castle Dyke, Sheffield	Mar. 2, 1872
214	HAINES, J. RICHARD, Adderley Green Colliery, near Longton ...	Nov. 7, 1874
215	HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire	1865
216	HALL, F. W., 1, Eslington Terrace, Jesmond Road, Newcastle-on-Tyne	Aug. 7, 1869
217	HALL, M., Lofthouse Station Collieries, near Wakefield	Sept. 5, 1868
218	HALL, M. S., M.E., Leasingthorne Colliery, near Bishop Auckland ...	Feb. 14, 1874
219	HALL, W., Spring Hill Mines, Cumberland County, Nova Scotia ...	Sept. 13, 1873
220	HALL, WM., East Hetton Colliery Office, Coxhoe, Co. Durham ...	Dec. 4, 1875
221	HALL, WILLIAM F., Haswell Colliery, Fence Houses	May 13, 1858
222	HANN, EDMUND, Aberaman, Aberdare	Sept. 5, 1868
223	HARBOTTLE, W. H., Orrell Colliery, near Wigan	Dec. 4, 1875
224	HARDY, JOS., 106, Senhouse Street, Maryport	June 2, 1877
225	HARGREAVES, WILLIAM, Rothwell Haigh, Leeds	Sept. 5, 1868
226	HARLE, RICHARD, Browney Colliery, Durham	April 7, 1877
227	HARLE, WILLIAM, Pagebank Colliery, near Durham	Oct. 7, 1876
228	HARRISON, R., Eastwood, near Nottingham	1861
229	HARRISON, T., Great Western Colliery, Pontypridd, Glamorganshire	Aug. 2, 1873
230	HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne	May 6, 1853
231	HARRISON, W. B., Brownhills Collieries, near Walsall	April 6, 1867
232	HASWELL, G. H., Messrs. Tangye Brothers, Birmingham	Mar. 2, 1872
233	HAY, J., Jun., Widdrington Colliery, Acklington	Sept. 4, 1869
234	HECKELS, MATTHEW, Castle Eden Colliery, Co. Durham	April 11, 1874
235	HECKELS, W. J., 29, Surtees Street, Bishop Auckland	May 2, 1868
236	HEDLEY, J. J., Consett Collieries, Leadgate, County Durham ...	April 6, 1872
237	HEDLEY, J. L., Flooker's Brook, Chester	Feb. 5, 1870
238	HEDLEY, T. F., Valuer, Sunderland	Mar. 4, 1871
239	HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)*	1864
240	HENDERSON, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
241	HEPPELL, T., Leafield House, Birtley, Fence Houses *(Mem. of Council)*	Aug. 6, 1863
242	HEPPELL, W., Western Hill, Durham	Mar. 2, 1872
243	HERDMAN, J., Park Crescent, Bridgend, Glamorganshire	Oct. 4, 1860
244	HESLOP, C., Lingdale Mines, Marske-by-the-Sea	Feb. 1, 1868
245	HESLOP, GRAINGER, Whitwell Colliery, Sunderland	Oct. 5, 1872
246	HESLOP, J., Hucknall Torkard Colliery, near Nottingham	Feb. 6, 1864
247	HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
248*	HEWITT, G. C., Coal Pit Heath Colliery, near Bristol	June 3, 1871
249	HEWLETT, A., Haigh Colliery, Wigan, Lancashire	Mar. 7, 1861
250	HICK, G. W., 14, Blenheim Terrace, Leeds	May 4, 1872
251	HIGSON, JACOB, 94, Cross Street, Manchester	1861

		ELECTED.
252	HILL, LESLIE C., Bartholomew House, London, E.C.	Nov. 6, 1875
253	HILTON, J., Wigan Coal and Iron Co., Limited, Wigan	Dec. 7, 1867
254	HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan	Aug. 3, 1865
255	HINDMARSH, THOMAS, Cowpen Lodge, Blyth, Northumberland ...	Sept. 2, 1876
256	HODGSON, J. W., Dipton Colliery, *via* Lintz Green Station	Feb. 5, 1870
257	HOLLIDAY, MARTIN, M.E., Peases' West Collieries, Crook	May 1, 1875
258	HOLMES, C., Grange Hill, near Bishop Auckland	April 11, 1874
259	HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent	Aug. 3, 1865
260	HOOD, A., 6, Bute Crescent, Cardiff	April 18, 1861
261	HOPE, GEORGE, Newbottle Colliery, Fence Houses	Feb. 3, 1877
262	HORNSBY, H., Hamsteels Colliery, near Durham	Aug. 1, 1874
263	HORSLEY, W., Whitehill Point, Percy Main	Mar. 5, 1857
264	HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c. ...	April 1, 1871
265	HOWARD, W. F., 13, Cavendish Street, Chesterfield	Aug. 1, 1861
266	HUDSON, JAMES, Albion Mines, Pictou, Nova Scotia	1862
267	HUGHES, H. E., The Hollies, Sedgley, near Dudley, Staffordshire ...	Nov. 6, 1869
268	HUMBLE, JOHN, West Pelton, Chester-le-Street	Mar. 4, 1871
269	HUMBLE, JOS., Staveley Works, near Chesterfield	June 2, 1866
270	HUNTER, J., Silkstone and Worsbro' Park Collieries, near Barnsley ...	Mar. 6, 1869
271	HUNTER, W., Monk Bretton Colliery, near Barnsley	Oct. 3, 1861
272	HUNTER, WM., Ridley Hall, Bardon Mill, Northumberland	Aug. 21, 1852
273	HUNTER, W. S., Moor Lodge, Newcastle-upon-Tyne	Feb. 1, 1868
274	HUNTING, CHARLES, Fence Houses	Dec. 6, 1866
275	HURST, T. G., F.G.S., Lauder Grange, Corbridge-on-Tyne	Aug. 21, 1852
276	JACKSON, C. G., Chamber Colliery Co., Limited, Hollinwood	June 4, 1870
277	JACKSON, W., Cannock Chase Collieries, Walsall	Feb. 14, 1874
278	JACKSON, W. G., Loscoe Grange, Normanton, Yorkshire	June 7, 1873
279	JARRATT, J., Broomside Colliery Office, Durham	Nov. 2, 1867
280	JEFFCOCK, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
281	JENKINS, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales	Dec. 6, 1862
282	JENKINS, WM., Consett Iron Works, Consett, Durham	May 2, 1874
283	JOHNSON, HENRY, Dudley, Worcestershire	Aug. 7, 1869
284	JOHNSON, JOHN, M. Inst. C.E., F.G.S., 21, Victoria Square, Newcastle	Aug. 21, 1852
285	JOHNSON, J., St. John's Colliery, Staveley, near Chesterfield	Mar. 7, 1874
286	JOHNSON, R. S., Sherburn Hall, Durham	Aug. 21, 1852
287	JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ...	April 10, 1869
288	JOICEY, W. J., Tanfield Lea Colliery, Burnopfield	Mar. 6, 1869
289	JOSEPH, D. DAVIS, Ty Draw, Pontypridd, South Wales	April 6, 1872
290	JOSEPH, T., Ty Draw, near Pontypridd, South Wales	April 6, 1872
291	KENDALL, JOHN D., Roper Street, Whitehaven	Oct. 3, 1874
292	KENNEDY, MYLES, M.E., Hill Foot, Ulverstone	June 6, 1868
293	KIMPTON, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
294	KIRKBY, J. W., Ashgrove, Windygates, Fife	Feb. 1, 1873
295	KIRSOPP, JOHN, Team Colliery, Gateshead	April 5, 1873
296	KNOWLES, A., High Bank, Pendlebury, Manchester	Dec. 5, 1856

		ELECTED.
297	KNOWLES, JOHN, Westwood, Pendlebury, Manchester	Dec. 5, 1856
298	KNOWLES, THOMAS, Ince Hall, Wigan	Aug. 1, 1861
299	KYRKE, R. H. V., Westminster Chambers, Wrexham	Feb. 5, 1870
300	LAMB, R., Cleator Moor Colliery, near Whitehaven	Sept. 2, 1865
301	LAMB, R. O., The Lawn, Ryton-on-Tyne	Aug. 2, 1866
302	LAMB, RICHARD W., Coal Owner, Newcastle-on-Tyne...	Nov. 2, 1872
303	LAMBERT, M. W., 9, Queen Street, Newcastle-on-Tyne	July 2, 1872
304	LANCASTER, JOHN, Bilton Grange, Rugby	July 4, 1861
305	LANCASTER, J., Jun., Anfield House, Willes Road, Leamington ...	Mar. 2, 1865
306	LANCASTER, S., Nantyglo & Blaina Steam Coal Collieries, Blaina, Mon.	Aug. 3, 1865
307	LANDALE, A., Lochgelly Iron Works, Fifeshire, N.B.	Dec. 2, 1858
308*	LAPORTE, HENRY, M.E., 80, Rue Royale, Brussels	May 5, 1877
309	LAVERICK, ROBT., West Rainton, Fence Houses	Sept. 2, 1876
310	LAWRENCE, HENRY, Grange Iron Works, Durham	Aug. 1, 1868
311	LAWS, H., Grainger Street West, Newcastle-on-Tyne	Feb. 6, 1869
312	LAWS, JOHN, Blyth, Northumberland	1854
313	LAWSON, Rev. E., Longhirst Hall, Morpeth	Dec. 3, 1870
314	LEBOUR, G. A., M.A., F.G.S., College of Physical Science, Newcastle *(Member of Council)*	Feb. 1, 1873
15	LEE, GEORGE, North Ormesby, Middlesbro'	June 4, 1870
316	LESLIE, ANDREW, Hebburn, Gateshead-on-Tyne	Sept. 7, 1867
317	LEVER, ELLIS, Bowdon, Cheshire	1861
318	LEWIS, HENRY, Annesley Colliery, near Nottingham	Aug. 2, 1866
319	LEWIS, W. H., 3, Bute Crescent, Cardiff	Aug. 4, 1877
320	LEWIS, WILLIAM THOMAS, Mardy, Aberdare	1864
321	LIDDELL, G. H., Somerset House, Whitehaven	Sept. 4, 1869
322	LINDOP, JAMES, Bloxwich, Walsall, Staffordshire	Aug. 1, 1861
323	LINSLEY, R., Cramlington Colliery, Northumberland	July 2, 1872
324	LINSLEY, S. W., Whitburn Colliery, Sunderland	Sept. 4, 1869
325	LISHMAN, T., Jun., Hetton Colliery, Fence Houses	Nov. 5, 1870
326	LISHMAN, WM., Witton-le-Wear...	1857
327	LISHMAN, WM., Bunker Hill, Fence Houses	Mar. 7, 1861
328	LIVESEY, C., Bradford Colliery, near Manchester	Aug. 3, 1865
329	LIVESEY, T., Bradford Colliery, Manchester	Nov. 7, 1874
330	LLEWELYN, L., c/o W. P. James, Abersychan Iron Works, nr. Pontypool	May 4, 1872
331	LOGAN, WILLIAM, Langley Park Colliery, Durham	Sept. 7, 1867
332	LONGBOTHAM, J., Norley Collieries, near Wigan	May 2, 1868
333	LONGRIDGE, J. A., 15, Great George Street, Westminster, London, S.W.	Aug. 21, 1852
334	LUPTON, A., F.G.S., Crossgates, near Leeds	Nov. 6, 1869
335	MADDISON, HENRY, The Lindens, Darlington	Nov. 6, 1875
336	MALING, C. T., Ford Pottery, Newcastle-on-Tyne	Oct. 5, 1872
337	MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds	1864
338	MARLEY, JOHN, 7, Bondgate, Darlington *(Member of Council)*	Aug. 21, 1852
339	MARLEY, J. W., 7, Bondgate, Darlington	Aug. 1, 1868
340	MARSHALL, F. C., Messrs. Hawthorn & Co., Newcastle	Aug. 2, 1866

		ELECTED.
341	MARSTON, W. B., Leeswood Vale Oil Works, Mold	Oct. 3, 1868
342	MARTEN, E. B., C.E., Pedmore, near Stourbridge	July 2, 1872
343	MATTHEWS, R. F., Hardwicke, Sedgefield	Mar. 5, 1857
344	MAUGHAN, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India	Nov. 7, 1863
345	MAY, GEORGE, Harton Colliery Offices, Tyne Docks, South Shields *(Member of Council)*	Mar. 6, 1862
346	McCREATH, J., 95, Bath Street, Glasgow	Mar. 5, 1870
347	McCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B.	Dec. 4, 1875
348	McCULLOCH, H. J., Horton House, 277, Camden Road, London, N....	Oct. 1, 1863
349	McCULLOCH, W., 178, Gresham House, Old Broad Street, London, E.C.	Nov. 7, 1874
350	McGHIE, T., Cannock, Staffordshire	Oct. 1, 1857
351	McMURTRIE, J., Radstock Colliery, Bath	Nov. 7, 1863
352	MEIK, THOMAS, C.E., 6, York Place, Edinburgh	June 4, 1870
353	MERIVALE, J. H., 2, Victoria Villas, Newcastle	May 5, 1877
354	MILLER, ROBERT, Beech Grove, Lock Park, Barnsley	Mar. 2, 1865
355	MILLS, M. H., Duckmanton Lodge, Chesterfield	Feb. 4, 1871
356	MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne	April 11, 1874
357	MITCHELL, JOSEPH, Bolton Hall, Rotherham	Feb, 14, 1874
358	MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham	Feb. 4, 1865
359	MOFFAT, T., Montreal Iron Ore Works, Whitehaven	Sept. 4, 1869
360	MONKHOUSE, JOS., 360, Gilcrux, Cockermouth	June 4, 1863
361	MOOR, T., Cambois Colliery, Blyth	Oct. 3, 1868
362	MOOR, WM., JUN., Hetton Colliery, Fence Houses	July 2, 1872
363	MOORE, R. W., Colliery Office, Whitehaven	Nov. 5, 1870
364	MORISON, D. P., 23, Ellison Place, Newcastle-on-Tyne	1861
365	MORRIS, W., Waldridge Colliery, Chester-le-Street, Fence Houses ...	1858
366*	MORTON, H. J., 4, Royal Crescent, Scarborough	1861
367	MORTON, H. T., Lambton, Fence Houses	Aug. 21, 1852
368	MOSES, WM., Barmoor Colliery, Beal	Mar. 2, 1872
369	MUCKLE, JOHN, 11, Oxford Terrace, Gateshead-on-Tyne	Mar. 7, 1861
370	MULVANY, W. T., Pêmpêlfort, Dusseldorf-on-the-Rhine	Dec. 3, 1857
371	MUNDLE, ARTHUR, 7, Collingwood Street, Newcastle-on-Tyne ...	June 5, 1875
372	MUNDLE, W., Redesdale Mines, Bellingham	Aug. 2, 1873
373*	NASSE, RUDOLPH, Konigl Bergwerks Director, Louisenthal, Saarbrucken, Prussia	1869
374	NAYLOR, J. T., 10, West Clayton Street, Newcastle-on-Tyne	Dec. 6, 1866
375	NELSON, J., C.E., 20, Wentworth Place, Newcastle-on-Tyne ...	Oct. 4, 1866
376	NEVIN, JOHN, Mirfield, Yorkshire	May 2, 1868
377	NEWALL, R. S., Ferndene, Gateshead	May 2, 1863
378	NICHOLSON, E., jun., Beamish Colliery, Chester-le-Street	Aug. 7, 1869
379	NICHOLSON, J. W.	Oct. 11, 1873
380	NICHOLSON, MARSHALL, Middleton Hall, Leeds	Nov. 7, 1863
381	NOBLE, CAPTAIN, Jesmond, Newcastle-upon-Tyne	Feb. 3, 1866
382	NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire ...	Oct. 6, 1864
383	NUTTALL, THOMAS, Broad Street, Bury, Lancashire	Sept. 11, 1875

		ELECTED.
384	OGDEN, JOHN M., Solicitor, Sunderland	Mar. 5, 1857
385	OGILVIE, A. GRAEME, 4, Great George Street, Westminster, London	Mar. 3, 1877
386	OLIVER, ROBERT, Charlaw Colliery, near Durham	Nov. 6, 1875
387	PACEY, T., Bishop Auckland	April 10, 1869
388	PALMER, A. S., Wardley Hall, near Newcastle-on-Tyne	July 2, 1872
389	PALMER, C. M., M.P., Quay, Newcastle-upon-Tyne	Nov. 5, 1852
390	PAMELY, C., Radstock Coal Works, near Bath	Sept. 5, 1868
391	PANTON, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867
392	PARKIN, C., Hutton-le-Hole, Kirby Moorside, York.	June 5, 1875
393	PARKIN, JOHN, Hutton-le-Hole, Kirby Moorside, York.	April 11, 1874
394	PARRINGTON, M. W., Wearmouth Colliery, Sunderland	Dec. 1, 1864
395	PARTON, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich	Oct. 2, 1869
396	PATTISON, JOHN, Engineer, Naples	Nov. 7, 1874
397	PEACE, M. W., Wigan, Lancashire	July 2, 1872
398	PEACOCK, DAVID, West Bromwich	Aug. 7, 1869
399	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
400	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbro', Yorkshire ...	Mar. 5, 1857
401	PEEL, JOHN, Wharncliffe, Silkstone Collieries, near Barnsley ...	Nov. 1, 1860
402	PEEL, JOHN, Horsley Colliery, Wylam-on-Tyne	Mar. 3, 1877
403	PEILE, WILLIAM, Ashfield, Workington	Oct. 1, 1863
404	PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester ...	Mar. 7, 1874
405	PICKUP, P. W., Rishton, near Blackburn	Feb. 6, 1875
406	PINCHING, ARCHD. E., South Indian Mining Co., Glenock Estate, Devala, Madras Residency, India	May 5, 1877
407	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
408	POTTER, A. M., Shiremoor Coll., Northumberland *(Member of Council)*	Feb. 3, 1872
409	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
410*	POTTER, W. A., Cramlington House, Northumberland *(Mem. of Council)*	1853
411	PRICE, JOHN, Messrs. Palmer & Co., Limited, Jarrow-on-Tyne ...	Mar. 3, 1877
412	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
413	PRIESTMAN, JON., Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
414	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
415	RAMSAY, J. A., Westbrook, Darlington	Mar. 6, 1869
416	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
417	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
418	REES, DANIEL, Glandare, Aberdare	1862
419	REFEEN, WM., Teplitz, Bohemia	Oct. 5, 1872
420	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
421	RICHARDS, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro' ...	Aug 5, 1876
422	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne	Mar. 2, 1865
423	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
424	RIDLEY, G., Trinity Chambers, Newcastle-on-Tyne	Feb. 4, 1865
425	RIDLEY, J. H., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ...	April 6, 1872
426	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
427	RIGBY, JOHN	Feb. 5, 1876

		ELECTED.
428	RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
429	RITSON, W. A., Shilbottle Colliery, near Alnwick	April 2, 1870
430	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
431	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire...	Nov. 5, 1870
432	ROBINSON, H., C.E., 7, Westminster Chambers, London	Sept. 3, 1870
433	ROBINSON, JOHN, Hebburn Colliery, near Newcastle-on-Tyne ...	Nov. 4, 1876
434	ROBINSON, R., Howlish Hall, near Bishop Auckland	Feb. 1, 1868
435	ROBSON, E., Middlesbro'-on-Tees...	April 2, 1870
436	ROBSON, J. S., Butterknowle Colliery, *via* Darlington...	1853
437	ROBSON, J. T., Cambuslang, Glasgow	Sept. 4, 1869
438	ROBSON, THOMAS, Lumley Colliery, Fence Houses	Oct. 4, 1860
439	ROGERSON, John, Croxdale Hall, Durham	Mar. 6, 1869
440	ROSCAMP, J., Rosedale Lodge, near Pickering, Yorkshire	Feb. 2, 1867
441	ROSS, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle	July 2, 1872
442	ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
443	ROTHWELL, R. P., 27, Park Place, New York, U.S.	Mar. 5, 1870
444	ROUTLEDGE, JOS., Ryhope Colliery, Sunderland	Sept. 11, 1875
445	ROUTLEDGE, J. L., Ryhope Colliery, Sunderland	Oct. 7, 1876
446	ROUTLEDGE, WM., Sydney, Cape Breton	Aug. 6, 1857
447	ROWLEY, J. C., Shagpoint Colliery, Otago, New Zealand	Dec. 4, 1875
448	RUTHERFORD, J., Halifax Coal Co., Ld., Albion Mines, Nova Scotia...	1852
449	RUTHERFORD, W., West Shield Row Colliery, *via* Chester-le-Street...	Oct. 3, 1874
450	RUTTER, THOS., Blaydon Main Colliery, Blaydon-on-Tyne	May 1, 1875
451	RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ...	Nov. 4, 1876
452	SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales	April 11, 1874
453	SCARTH, W. T., Raby Castle, Darlington	April 4, 1868
454	SCOTT, ANDREW, Broomhill Colliery, Acklington	Dec. 7, 1867
455	SCOTT, C. F., Gateshead Fell Colliery, Gateshead-on-Tyne	April 11, 1874
456	SCOULAR, G., Parkside, Frizington, Cumberland	July 2, 1872
457	SEDDON, J. F., Great Harwood Collieries, near Accrington	June 1, 1867
458	SHALLIS, F. W., Pritchard & Sons, 9, Gracechurch Street, London ...	April 6, 1872
459	SHAW, W., Jun., Wolsingham, *via* Darlington...	June 3, 1871
460	SHIEL, JOHN, Framwellgate Colliery, County Durham	May 6, 1871
461	SHONE, ISAAC, Pentrefelin House, Wrexham	1858
462	SHORTREDE, T., Park House, Winstanley, Wigan	April 3, 1856
463	SHUTE, C. A., Westoe, South Shields	April 11, 1874
464	SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne	Dec. 6, 1866
465	SIMPSON, JOS., Springhill Mines, Cumberland Co., Nova Scotia ...	Mar. 3, 1873
466	SIMPSON, J. B., Hedgefield House, Blaydon-on-Tyne *(Mem. of Council)*	Oct. 4, 1860
467	SIMPSON, J. C.	April 7, 1877
468	SIMPSON, R., Moor House, Ryton-on-Tyne	Aug. 21, 1852
469	SIMPSON, ROBT., Drummond Coll., Westville, Pictou, Nova Scotia ...	Dec. 4, 1875
470	SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ...	July 2, 1872
471	SMALL, G., Duffield Road, Derby	June 4, 1870
472	SMITH, G. F., Grovehurst, Tunbridge Wells	Aug. 5, 1853
473	SMITH, J., Bickershaw Colliery, Leigh, near Manchester	Mar. 7, 1874

		ELECTED.
474*	SMITH, R. CLIFFORD, Parkfield, Swinton, Manchester	Dec. 5, 1874
475	SMITH, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester...	May, 5, 1877
476	SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne	Dec. 5, 1874
477	SNOWDON, T., jun., West Bitchburn Coll., nr. Tow Law, *via* Darlington	Sept, 4, 1869
478	SOPWITH, A., Cannock Chase Collieries, near Walsall	Aug. 1, 1868
479	SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ...	Mar. 3, 1877
480	SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ...	Aug. 3, 1865
481	SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan	May 2, 1874
482	SPENCE, JAMES, Clifton and Melgramfitz Collieries, Workington ...	Nov. 7, 1874
483	SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne	Sept. 4, 1869
484	SPENCER, M., Newburn, near Newcastle-on-Tyne	Sept. 4, 1869
485	SPENCER, T., Ryton, Newcastle-on-Tyne	Dec. 6, 1866
486	SPENCER, W., 39, New Walk, Leicester	Aug. 21, 1852
487	STEAVENSON, A. L., Durham ... ... (VICE-PRESIDENT)	Dec. 6, 1855
488	STEELE, CHARLES R., Alneburgh House, near Maryport	Mar. 3, 1864
489	STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W.	Oct. 4, 1860
490	STEPHENSON, W. H., Elswick House, Newcastle-on-Tyne	Mar. 7, 1867
491	STEVENSON, R., Lochgelly Iron Works, Lochgelly, Fifeshire	Feb. 5, 1876
492	STOBART, W., Pepper Arden, Northallerton	July 2, 1872
493	STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire	Feb. 5, 1876
494	STRAKER, JOHN, Stagshaw House, Corbridge-on-Tyne	May 2, 1867
495	STRAKER, J. H., Willington House, Co. Durham	Oct. 3, 1874
496	STRATTON, T. H. M., Tredegar, South Wales	Dec. 3, 1870
497	SWALLOW, J., Pontop Hall, Lintz Green	May 2, 1874
498	SWALLOW, R. T., Springwell, Gateshead	1862
499	SWAN, H. F., Shipbuilder, Newcastle-on-Tyne	Sept. 2, 1871
500	SWAN, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
501	SWANN, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London	Aug. 7, 1875
502	TATE, SIMON, Kimblesworth Colliery, Co. Durham	Sept. 11, 1875
503	TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
504	TAYLOR, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
505	TAYLOR-SMITH, THOMAS, Greencroft Park	Aug. 2, 1866
506	THOMAS, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
507	THOMPSON, JOHN, Boughton Hall, Chester	Sept. 2, 1865
508	THOMPSON, R., Jun., Rodridge House, Wingate, Co. Durham ...	Sept. 7, 1867
509	THOMPSON, T. C., Milton Hall, Carlisle	May 4, 1854
510	THOMSON, JOHN, Eston Mines, by Middlesbro'	April 7, 1877
511	THOMSON, JOS. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
512	TINN, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol ...	Sept. 7, 1867
513	TYLDEN-WRIGHT, C., Shireoaks Colliery, Worksop, Notts	1862
514	TYSON, WM. JOHN, 15, Foxhouses Road, Whitehaven	Mar. 3, 1877
515	TYZACK, D., Birtley, Chester-le-Street, Durham	Feb. 14, 1874
516	TYZACK, WILFRED, Tanfield Lea Coll., Lintz Green Station, Newcastle	Oct. 7, 1876
517	VIVIAN, JOHN, Diamond Boring Company, Whitehaven	Mar. 3, 1877

		ELECTED.
518	WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
519	WALKER, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871
520	WALKER, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
521	WALKER, W., Saltburn-by-the-Sea	Mar. 5, 1870
522	WALLACE, HENRY, Trench Hall, Gateshead	Nov. 2, 1872
523	WARD, H., Rodbaston Hall, near Penkridge, Stafford...	Mar. 6, 1862
524	WARDALE, JOHN D., M.E., Redheugh Engine Works, Gateshead ...	May 1, 1875
525	WARDELL, S. C., Doe Hill House, Alfreton	April 1, 1865
526	WARRINGTON, J.	Oct. 6, 1859
527	WATSON, H., High Bridge Works, Newcastle-on-Tyne	Mar. 7, 1868
528	WATSON, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
529	WATSON, M., Flimby and Broughton Moor Collieries, near Maryport..	Mar. 7, 1868
530	WEEKS, J. G., Bedlington Collieries, Bedlington *(Member of Council)*	Feb. 4, 1865
531	WESTMACOTT, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
532	WHATELY, W. L.	Dec. 4, 1875
533	WHITE, H., Weardale Coal Company, Tow Law, near Darlington ...	1866
534	WHITE, J. F., M.E., Wakefield	July 2, 1872
535	WHITE, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
536	WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
537	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
538	WHITELAW, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
539	WHITTEM, THOS. S., Wyken Colliery, near Coventry	Dec. 5, 1874
540	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington... ...	Dec. 5, 1868
541	WIGHT, W. H., Cowpen Colliery, Blyth...	Feb. 3, 1877
542	WILD, J. G., Hedley Hope Collieries, Tow Law, by Darlington ...	Oct. 5, 1867
543	WILLIAMS, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
544	WILLIAMS, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
545	WILLIAMSON, JOHN, Chemical Manufacturer, South Shields... ...	Sept. 2, 1871
546	WILLIAMSON, JOHN, Cannock, &c., Collieries, Hednesford	Nov. 2, 1872
547	WILLIS, J., 14, Portland Terrace, Newcastle *(Member of Council)*	Mar. 5, 1857
548	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton... ...	Nov. 5, 1852
549	WILSON, ROBERT, Flimby Colliery, Maryport	Aug. 1, 1874
550	WILSON, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
551	WINTER, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
552	WOOD, C. L., Freeland, Bridge of Earn, Perthshire	1853
553	WOOD, LINDSAY, Southill, Chester-le-Street (PAST PRESIDENT, *Member of Council)*	Oct. 1, 1857
554	WOOD, THOMAS, Rainton House, Fence Houses	Sept. 3, 1870
555	WOOD, W. H., West Hetton, Ferryhill	1856
556	WOOD, W. O., Trimdon Grange Colliery, Co. Durham...	Nov. 7, 1863
557	WOOLCOCK, HENRY, St. Bees, Cumberland	Mar. 3, 1873
558	WRIGHT, G. H., 12, Trumpington Street, Cambridge...	July 2, 1872
559	WRIGHTSON, T., Stockton-on-Tees	Sept. 13, 1873
560	YOUNG, PHILIP, 84, Bucknall Old Road, Hanley	Oct. 11, 1873

Ordinary Members.

		ELECTED.
1	ACKROYD, WM., Jun., M.E., Morley Main Collieries, Morley, nr. Leeds	Feb. 7, 1880
2	BELL, C. E., Park House, Durham	Dec. 3, 1870
3	BRAMALL, HENRY, M.I.C.E., St. Helen's, Lancashire	Oct. 5, 1878
4	BROJA, RICHARD, Mining Engineer, Ostwall, Dortmund	Nov. 6, 1880
5	BUTLER, W. F., C.E., Cymman Hall, near Wrexham	Feb. 7, 1880
6	CRANSTON, JOHN GREY, 22, Grey Street, Newcastle-on-Tyne ...	Aug. 6, 1881
7	DACRES, THOMAS, Dearham Colliery, *via* Carlisle	May 4, 1878
8*	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
9	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
10	GEDDES, GEORGE H., 142 Princes Street, Edinburgh	Oct. 1, 1881
11	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
12	GOUDIE, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878
13	HARBOTTLE, JOHN, Skelton Park Mines, Marske-by-the-Sea	June 10, 1882
14	KELLETT, WILLIAM, Wigan	June 1, 1878
15	LANCASTER, JOHN, Auchinbeath, &c., Collieries, Lanarkshire ...	Sept. 7, 1878
16	LAWS, W. G., Civil Engineer, Newcastle-on-Tyne	Oct. 2, 1880
17	LLEWELLIN, DAVID MORGAN, F.G.S., Glanwern Offices, Pontypool ...	May 14, 1881
18	MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ...	Feb. 15, 1879
19	POTTS, JOS., Jun., Architect, &c., North Cliff, Roker, Sunderland ...	Dec. 6, 1879
20	PRIOR, EDWARD G., Victoria, British Columbia...	Feb. 7, 1880
21	ROGERS, WILLIAM, M.E., 19, King Street, Wigan	Nov. 2, 1878
22	RUSSELL, ROBERT, M.E., Coltness Iron Works, Newmains, N.B. ...	Aug. 3, 1878
23	SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne	May 4, 1878
24	TOPPING, WALTER, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan	Mar. 2, 1878
25	WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven	Nov. 19, 1881
26	WINSTANLEY, ROBT., M.E., 32, St. Ann's Street, Manchester... ...	Sept. 7, 1878

Associate Members.

1	ARNOLD, THOS., Mineral Surveyor, Castle Hill, Greenfields, Llanelly	Oct. 2, 1880
2	AUDUS, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne	Aug. 7, 1880
3	BAILES, E. T., Wingate, Ferryhill	June 7, 1879
4	BARNES, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
5	BARRETT, CHARLES ROLLO, New Seaham, Seaham Harbour	Nov. 7, 1874
6	BERKLEY, R. W., Marley Hill Colliery, Gateshead	Feb. 14, 1874
7	BEWICK, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
8	BIRD, W. J., Wingate Colliery, Durham	Nov. 6, 1875
9	BOWLKER, T. J., Heddon Vicarage, Wylam-on-Tyne	May 5, 1877
10	BROUGH, THOMAS, Seaham Colliery, Seaham Harbour	Feb. 1, 1873
11	BROWN, M. W., 7, Elswick Park, Newcastle-on-Tyne	Oct. 7, 1871
12	BROWN, W. B., Springfield, Wavertree, Liverpool	Mar. 2, 1878
13	BRUCE, JOHN, Cannock Chase Colliery, near Walsall	Feb. 14, 1874

		ELECTED.
14	BULMAN, H. F., West Rainton, Fence Houses	May 2, 1874
15	BUNNING, C. Z., 49 and 50, Parliament Street, London, S.W. ...	Dec. 6, 1873
16	BURNLEY, C. E., Aybrigg Farm, near Wakefield	April 11, 1874
17	CABRERA, FIDEL, c/o H. Kendall & Son, 12, Gt. Winchester St., London	Oct. 6, 1877
18	CHARLTON, W. A., Tangye Bros., 25, Lincoln St., Gateshead-on-Tyne	Nov. 6, 1880
19	CLARK, ROBT., So. Medomsley Coll., Dipton, Lintz Green, nr. Newcastle	Sept. 11, 1875
20	CLOUGH, JAMES, Bedlington Collieries, near Morpeth...	April 5, 1873
21	COBBOLD, C. H., Mineral Office, Elsecar, near Barnsley	May 3, 1873
22	COCHRANE RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878
23	COCKSON, CHARLES, Wigan Coal and Iron Co., Limited, Wigan ...	April 22, 1882
24	COOPER, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
25	DALZIEL, W. G., 2, Pembroke Terrace, Cardiff	Sept. 7, 1878
26	DODD, M., Jun., Walbottle, Newcastle-on-Tyne	Dec. 4, 1875
27	DOUGLAS, JOHN, Sen., Seghill Colliery, Dudley, Northumberland ...	April 22, 1882
28	DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland ...	April 22, 1882
29	DOUGLAS, M. H., Marsden Colliery, South Shields	Aug. 2, 1879
30	DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., Municipal Chambers, Charters Towers, *via* Townsville, Queensland, Australia	Mar. 1, 1879
31	EDEN, C. H., Etherley House, Darlington	Sept. 13, 1873
32	EDGE, J. C., Ince Hall Coal and Cannel Co., Limited, Wigan ...	Dec. 5, 1874
33	EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
34	FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street	Aug. 7, 1880
35	FARROW, JOSEPH, Brotton Mines, Saltburn-by-the-Sea	Feb. 11, 1882
36	FRYAR, MARK, Denby Colliery, Derby	Oct. 7, 1876
37	GERRARD, JAMES, Ince Hall Coal and Cannel Company, Wigan ...	Mar. 3, 1873
38	GREENER, T. Y., Rainford Collieries, St. Helen's, Lancashire... ...	July 2, 1872
39	GREENER, W. J., Pemberton Colliery, Wigan	Mar. 2, 1878
40	GRESLEY, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
41	HAMILTON, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
42	HARRIS, W. S., Andrews House, near Gateshead	Feb. 14, 1874
43	HARRISON, J. W., M.E., Gildersome, near Leeds	Aug. 3, 1878
44	HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ...	Dec. 2, 1871
45	HENRY, GEO. J., Stowmarket Gun Cotton Co., Stowmarket	Nov. 19, 1881
46	HUMBLE, STEPHEN, Uttoxeter Road, Derby	Oct. 6, 1877
47	JEPSON, H., 54, Old Elvet, Durham	July 2, 1872
48	JOHNSON, W., Abram Colliery, Wigan	Feb. 14, 1874
49	JORDAN, J. J., Mina de S. Domingos, Mertola, Portugal	Mar. 3, 1873
50	LEACH, C. C., Bedlington Collieries, Bedlington	Mar. 7, 1874
51	LIDDELL, J. M., 10, Claremont Place, Newcastle-on-Tyne	Mar. 6, 1875
52	LISLE, J., Washington Colliery, County Durham	July 2, 1872

		ELECTED.
53	MACCABE, H. O., Russell Vale, Wollongong, New South Wales ...	Sept. 7, 1878
54	MACDONALD, JOHN G. A., Warora Colliery, Central Provinces, India	April 22, 1882
55	MADDISON, THOS. R., Thornhill Collieries, near Dewsbury	Mar. 3, 1877
56	MAKEPEACE, H. R., Bog & Home Farm Colls., Larkhall, Hamilton, N.B.	Mar. 3, 1877
57	MARKHAM, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
58	MELLY, E. F., Griff Collieries, Nuneaton	Oct. 5, 1878
59	MERIVALE, W., C.E.	Mar. 5, 1881
60	MILLER, D. S., Neston Collieries, Cheshire	Nov. 7, 1874
61*	MILLER, N., Kurhurballee Coll., East India Railway, Chord Line, Bengal	Oct. 5, 1878
62	MOORE, WILLIAM, Upleatham Mines, Marske-by-the-Sea	Nov. 19, 1881
63	MOREING, C. A., 34, Clement's Lane, London, E.C.	Nov. 7, 1874
64	MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B.	Dec. 4, 1880
65	PRICHARD, W., Nav. and Deep Duffryn Colls., Mountain Ash, So. Wales	Dec. 7, 1878
66	PRINGLE, JOS. Manager, Coxlodge Colliery, So. Gosforth, Newcastle	Mar. 5, 1881
67	RATHBONE, EDGAR P., 2, Great George Street, Westminster, London	Mar. 7, 1874
68	SAISE, W., D. Sc., Giridi, E.I.R., Chord Line, *via* Muddapore, Bengal	Nov. 3, 1877
69	SAWYER, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent	Dec. 6, 1873
70	SMITH, J. BAGNOLD, The Laurels, Chesterfield	Nov. 2, 1878
71	SMITH, THOS. READER, M.E., Thorncliffe Collieries, near Sheffield ...	Feb. 5, 1881
72	STOBART, F., Blue House, Washington, Co. Durham	Aug. 2, 1873
73	STOBBS, FRANK, 1, Queen Street, Newcastle	Oct. 1, 1881
74	STONES, T. H., Wigan Coal & Iron Co., Westleigh, nr. Leigh, Lancashire	Nov. 7, 1874
75	TAIT, JAMES, Estate Agent, Garmondsway Moor, Coxhoe	May 14, 1881
76	TELFORD, W. H., Cramlington Colliery, Northumberland	Oct. 3, 1874
77	TURNBULL, GEORGE, Seaham Colliery, Seaham Harbour	Oct. 4, 1879
78	VITANOFF, GEO. N., Messrs. Hawks, Crawshay, & Sons, Gateshead ...	April 22, 1882
79	WALTERS, HARGRAVE, Coton Park and Linton Coll., Burton-on-Trent	June 4, 1881
80	WALTON, J. COULTHARD, South Benwell Colliery, Newcastle-on-Tyne	Nov. 7, 1874
81*	WARD, T. H., Manager, Kuldiha Colliery, Bengal Coal Co., Limited, Giridi, East Indian Railway, Bengal, India	Aug. 7, 1882
82	WARDLE, EDWARD, M.E., Craghead Colliery, Chester-le-Street ...	Feb. 5, 1881
83	WEEKS, R. L., Willington, Co. Durham	June 10, 1882

Students.

1	ATKINSON, A. A., 4, Belle Vue Crescent, Sunderland	Aug. 3, 1878
2	ATKINSON, E. E., Westbourne House, Long Benton	Nov. 4, 1876
3	ATKINSON, FRED., Maryport	Feb. 14, 1874
4	AYTON, E. F., Heddon Colliery, Wylam-on-Tyne	Feb. 5, 1876
5	AYTON, HENRY, Seaton Delaval Colliery, Dudley, Northumberland ...	Mar. 6, 1875

		ELECTED.
6	BAUMGARTNER, W. O., East Hetton Coll. Office, Coxhoe, Co. Durham	Sept. 6, 1879
7	BELL, GEO. FRED., 25, Old Elvet, Durham	Sept. 6, 1879
8	BIRD, HARRY, Fawler Iron Mines, Charlbury	April 7, 1877
9	BLACKETT, W. C., Jun., 6, Old Elvet, Durham...	Nov. 4, 1876
10	BLAKELEY, A. B., Hollyroyd, Dewsbury	Feb. 15, 1879
11	BRAMWELL, HUGH, 20, Beverley Terrace, Cullercoats	Oct. 4, 1879
12	BROWN, C. GILPIN, Hetton Colliery, Fence Houses	Nov. 4, 1876
13	BUCKHAM, R.	Oct. 5, 1878
14	CANDLER, T. E., East Lodge, Crook, Darlington	May 1, 1875
15	CHANDLEY, CHARLES, Atherton Collieries, near Manchester	Nov. 6, 1880
16	CHAPMAN, ALF. C., Mining Offices, Marsden, South Shields	Oct. 4, 1879
17	CHILD, H.	Feb. 15, 1879
18	COX, L. CLIFFORD, Ravenstone, near Ashby-de-la-Zouch	April 1, 1876
19	CRAWFORD, T. W., Peases' West Collieries, Crook, by Darlington ...	Dec. 4, 1875
20	CRONE, F. E., Killingworth House, near Newcastle	Sept. 2, 1876
21	CURRY, W. THOS., Wardley Colliery, Newcastle-on-Tyne	Sept. 4, 1880
22	DAVIDSON, C. C., Ore Bank House, Bigrigg, *via* Carnforth, Cumberland	Nov. 4, 1876
23	DAVIS, KENNETH M., Towneley and Stella Collieries, Ryton-on-Tyne	April 5, 1879
24	DEPLEDGE, M. F., Eston, Middlesbrough	April 7, 1877
25	DONKIN, WM., Usworth Colliery, Washington Station, Co. Durham ...	Sept. 2, 1876
26	DOUGLAS, ARTHUR STANLEY, Croxdale Colliery, near Durham ...	June 1, 1878
27	DOWSON, W. C., Belle Vue House, Escomb, near Bishop Auckland ...	Mar. 2, 1878
28	DUNN, A. F., Poynton, Stockport, Cheshire	June 2, 1877
29	DURNFORD, H. ST. JOHN, Low Stublin Colliery, near Rotherham ...	June 2, 1877
30	EVANS, DAVID L., Messrs. Dalziel & Evans, Cardiff	May 4, 1878
31	FERENS, FREDERICK J., 220, Gilesgate, Durham	Dec. 4, 1880
32	FLETCHER, JOHN E., Ellesmere Park, Eccles, near Manchester ...	Dec. 1, 1877
33	FORSTER, C. W., Backworth House, Newcastle	June 10, 1882
34	FORSTER, THOMAS E., Backworth, Newcastle-on-Tyne	Oct. 7, 1876
35	FOWLER, ROBERT, Wearmouth Colliery, Sunderland	Dec. 2, 1876
36	GALLWEY, ARTHUR P., c/o J. W. Harriman, Porte of Spain, Trinidad	Oct. 2, 1880
37	GILCHRIST, J. R., Newbottle Colliery Offices, Fence Houses	Feb. 3, 1877
38	GORDON, CHAS., St. Chads, Lichfield	May 5, 1877
39	GOULD, ALEX., Cowpen Colliery, Blyth	Dec. 1, 1877
40	GREEN, FRANCIS W., Harton Colliery Offices, South Shields ...	April 22, 1882
41	GREIG, J., Browney Colliery, Durham	Feb. 5, 1881
42	GUTHRIE, JAMES KENNETH, Ryton-on-Tyne	Mar. 1, 1879
43	HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876
44	HALLAS, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
45	HARE, SAMUEL, Gladstone Street, Crook	Aug. 2, 1879
46	HARRISON, ROBERT J., Backworth Colliery, near Newcastle-on-Tyne	May 1, 1875
47	HARRISON, R. W., Public Wharf, Leicester	Mar. 3, 1877

		Elected,
48	Hedley, Sept. H., Wardley, Newcastle-on-Tyne	Feb. 15, 1879
49	Hendy, J. C. B., Wear Terrace, Bishop Auckland	Sept. 2, 1876
50	Heslop, Septimus, Urpeth, Chester-le-Street	Dec. 4, 1880
51	Heslop, Thomas, Storey Lodge Colliery, Cockfield, *via* Darlington...	Oct. 2, 1880
52	Hill, Leonard, Normanby Mines, near Middlesbrough	Oct. 6, 1877
53	Hooper, Edward, Haydon Bridge, Northumberland...	June 4, 1881
54	Howard, Walter, 13, Cavendish Street, Chesterfield	April 13, 1878
55	Hudson, Joseph G. S., Albion Mines, Pictou County, Nova Scotia...	Mar. 2, 1878
56	Humble, Joicey, 17, Westmorland Terrace, Newcastle-on-Tyne ...	Mar. 3, 1877
57	Humble, Robert, 17, Westmorland Terrace, Newcastle-on-Tyne ...	Sept. 2, 1876
58	Hunter, John P., Backworth Colliery, near Newcastle-on-Tyne ...	Oct. 6, 1877
59	Jobling, Thos. E., Coxlodge Colliery, by Kenton, Newcastle-on-Tyne	Oct. 7, 1876
60	Kayll, A. C., Felling Colliery, Gateshead	Oct. 7, 1876
61	Kirkhouse, E. G., Medomsley, Lintz Green, Newcastle-on-Tyne ...	Aug. 3, 1878
62	Kirkup, Philip, Esh Colliery, near Durham	Mar. 2, 1878
63	Kirton, Hugh, Browney Colliery, Durham	April 7, 1877
64	Lindsay, Clarence S., Marsden, South Shields	Mar. 4, 1876
65	Liveing, E. H., 52, Queen Anne Street, Cavendish Square, London	Sept. 1, 1877
66	Locke, Ernest G.	Dec. 2, 1876
67	Longbotham, R. H., Ormskirk Road, Newton, Wigan	Sept. 2, 1876
68	Mackinlay, Thos. B., West Pelton Colliery, Chester-le-Street ...	Nov. 1, 1879
69	Marston, Frank, Bromfield Hall, Mold	Aug. 7, 1882
70	Mundle, Robert, Clayton Park Square, Newcastle-on-Tyne ...	Mar. 6, 1875
71	Murray, W. C., Weed Park, Dipton, *via* Lintz Green Station ...	Oct. 4, 1879
72	Murton, Charles J., Jesmond Villas, Newcastle-on-Tyne	Mar. 6, 1880
73	Nicholson, Jos. C., Wear Steel and File Works, Sunderland ...	Feb. 3, 1877
74	Nicholson, J. H., Cambois Colliery, Blyth, Northumberland ...	Oct. 1, 1881
75	Noble, J. C., Usworth Hall, near Washington Station, Co. Durham...	May 5, 1877
76	Ornsby, R. E., Seaton Delaval Colliery, Dudley, Northumberland ..	Mar. 6, 1875
77	Palmer, Henry, East Howle Colliery, near Ferryhill	Nov. 2, 1878
78	Pattison, Jos. W., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
79	Peake, Charles Edwd., Silksworth Colliery, Sunderland	Nov. 3, 1877
80	Peake, R. C., Harton Colliery Offices, South Shields	Feb. 7, 1880
81	Peart, A. W., Powell Duffryn Collieries, Aberdare	Nov. 4, 1876
82	Pike, Arnold, Cwmaman Colliery, near Aberdare, Wales	Feb. 5, 1881
83	Potter, E. A., Cramlington House, Northumberland	Feb. 6, 1875
84	Prest, J. J., St. Helen's Colliery, Bishop Auckland	May 1, 1875
85	Price, S. R., Houghton Main Colliery, near Barnsley, Yorkshire ...	Nov. 3, 1877
86	Pringle, H. A., Lofthouse Mines, Saltburn-by-the-Sea	Oct. 2, 1880
87	Pringle, Hy. Geo., Tanfield Lea Coll., Lintz Green Station, Newcastle	Dec. 4, 1880
88	Proctor, C. P., Shibden Hall Collieries, near Halifax, Yorkshire ...	Oct. 7, 1876

		ELECTED.
89	REED, R., North Seaton Colliery, Morpeth	Feb. 3, 1877
90	RICHARDSON, R. W. P., Office of General Manager, Cedral Mining and Smelting Co.'s Mines, Villa de Musquiz Coalmila, Mexico ...	Mar. 4, 1876
91	ROBINSON, FRANK, Ackhurst Hall, Wigan	Sept. 2, 1876
92	ROBINSON, GEO., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
93	ROBSON, HARRY N., 3, North Bailey, Durham	Dec. 4, 1875
94	ROBSON, THOS. O., Medomsley, Newcastle-on-Tyne	Sept. 11, 1875
95	ROUTLEDGE, W. H., Staveley Coal and Iron Co. Limited, Chesterfield	Oct. 7, 1876
96	SCARTH, R. W., Stanghow House, Stanghow, *via* Marske-by-the-Sea	Dec. 4, 1875
97	SCOTT, JOSEPH SAMUEL, East Hetton Colliery, Coxhoe	Nov. 19, 1881
98	SCOTT, WALTER, Cornsay Colliery, Lanchester...	Sept. 6, 1879
99	SCOTT, WM., Brandon Colliery Offices, near Durham	Mar. 4, 1876
100	SMITH, THOS., Leadgate, Co. Durham	Feb. 15, 1879
101	SMITH, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire	May 5, 1877
102	SOUTHERN, E. O., 5, Fenwick Terrace, Jesmond, Newcastle-on-Tyne	Dec. 5, 1874
103	SOUTHERN, THOMAS, North Biddick Colliery, Washington Station ...	Dec. 17, 1881
104	SPENCE, R. F., Cramlington	Nov. 2, 1878
105	STOBART, HENRY TEMPLE, Eton Villa, Saltburn-by-the-Sea	Oct. 2, 1880
106	STOKER, ARTHUR P., Birtley, near Chester-le-Street	Oct. 6, 1877
107	TODD, JOHN T., Hetton-le-Hole, Fence Houses...	Nov. 4, 1876
108	TODNER, W. J. S., 33, Beaumont Street, Elswick, Newcastle-on-Tyne	Sept. 6, 1879
109	TOPHAM, EDWARD C., Marsden, South Shields	Nov. 3, 1877
110	TURNBULL, H. B., Framwellgate Colliery, near Durham	Nov. 19, 1881
111	WALKER, F. W., Aldbro', Darlington	Sept. 2, 1876
112	WAUGH, CHARLES L., The Burroughes, Cockermouth, Cumberland ...	Nov. 19, 1881
113	WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
114	WILSON, A. P., 8, Powis Villas, Clifton Hill, Brighton	Oct. 1, 1881
115	WILSON, J. D., 8, Walker Terrace, Gateshead-on-Tyne	Sept. 11, 1875

Subscribing Collieries.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Haswell Colliery, Fence Houses.
3 Hetton Collieries, Fence Houses.
4 Lambton Collieries, Fence Houses.
5 Londonderry Collieries.
6 North Hetton Colliery, Fence Houses.
7 Ryhope Colliery, near Sunderland.
8 Seghill Colliery, Northumberland.
9 South Hetton and Murton Collieries.
10 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
11 Throckley Colliery, Newcastle-on-Tyne.
12 Wearmouth Colliery, Sunderland.
13 Whitworth Colliery, Ferryhill.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

f

and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. And whereas in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said Lindsay Wood, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. Now know ye that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 8.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____
_____
_____
} Five Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two Members.
_____

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____
_____
_____

ASSOCIATE MEMBERS:—

_____
_____

HONORARY MEMBERS:—

_____
_____

STUDENTS:—

_____
_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM H.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18 you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of _____ 18 _____ at Two o'Clock.

PRESIDENT—ONE NAME only to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.

_____ } New Nominations.
_____

VICE-PRESIDENTS—SIX NAMES only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

_____ } Vice-Presidents for the current year eligible for re-election.
_____
_____
_____

_____ } New Nominations.
_____
_____
_____

COUNCIL—EIGHTEEN NAMES only to be returned, or the vote will be lost.

_____ } Members of the Council for the current year eligible for re-election.
_____
_____
_____
_____
_____
_____
_____
_____
_____

_____ } New Nominations.
_____
_____
_____
_____
_____
_____
_____
_____
_____

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

_____

_____

_____

_____

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

As President _____

As Vice-President _____

As Councillors _____

[FORM L.]

Admit

of

to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

FRIDAY, SEPTEMBER 16TH, 1881.

MEETING IN CLEVELAND.

AT the invitation of Messrs. Bell Brothers, conveyed through Mr. A. L. Steavenson, about one hundred members of the Institute visited the Skelton Park Ironstone Mine and the Sinking operations at Lumpsey, on Friday, the 16th September, the North-Eastern Railway Company kindly providing special accommodation for the excursion.

As the arrangement was more particularly made to allow those who had not previously had any opportunity of witnessing sinking operations to become acquainted with the nature of the process, a large number of students took advantage of the occasion, and availed themselves of Messrs. Bell's kindness by descending the shaft and examining all the details of the operation.

The company afterwards dined at the "Zetland" Hotel, Saltburn, Mr. William Cochrane in the chair, when votes of thanks were unanimously passed to Messrs. Bell Brothers and Mr. A. L. Steavenson for their kindness.

It is the intention of Mr. Steavenson to read a paper at an early date, describing the machinery that was inspected, and giving some details of the mine and neighbourhood.

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, OCTOBER 1ST, 1881, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEO. B. FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the general meeting held on August 6th, and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

ORDINARY MEMBER—

Mr. GEORGE H. GEDDES, Mining Engineer, 142, Princes Street, Edinburgh.

ASSOCIATE MEMBER—

Mr. FRANK STOBBS (Manager, Messrs. Thomas and William Smith), 1, Queen Street, Quay, Newcastle-upon-Tyne.

STUDENTS—

Mr. ARTHUR P. WILSON, Brancepeth, near Durham.

Mr. J. H. NICHOLSON, Cambois Colliery, Blyth, Northumberland.

The following were nominated for election at the next meeting:—

ORDINARY MEMBER—

Mr. WILLIAM E. WALKER, M.E., Lowther Street, Whitehaven.

ASSOCIATE MEMBERS—

Mr. WILLIAM MOORE, Upleatham Mines, Marske-by-the-Sea.

Mr. GEORGE J. HENRY, Stowmarket Gun-Cotton Works, Stowmarket.

STUDENTS—

Mr. CHARLES L. WAUGH, The Burroughs, Cockermouth.

Mr. JOSEPH SAMUEL SCOTT, East Hetton Colliery, Coxhoe.

Mr. HENRY B. TURNBULL, Framwellgate Colliery, near Durham.

The following notes upon Messrs. Pernolet and Aguillon's "Report upon the Working and Regulation of Fiery Mines in England," were read by Mr. A. L. Steavenson:—

REPORT UPON THE WORKING AND REGULATION OF FIERY MINES IN ENGLAND BY MESSRS. PERNOLET AND AGUILLON.*

REVIEWED BY A. L. STEAVENSON.

HAVING, through the courtesy of H.M. Inspector of Mines for the Durham and Cleveland district, received a copy of this Report, the reviewer found, as his previous knowledge of M. Pernolet, one of the Commissioners, led him to expect, that it was a most interesting and useful review of all the laws, facts, and customs appertaining to the subject under consideration, given with the minute detail characteristic of the technical education possessed by French mining engineers, but that it often asserted opinions which seemed to require refutation.

The report, primarily divided into nine chapters, is subdivided into numerous sections. The nine leading divisions are devoted to the following subjects, the enumeration of which will at once convey an idea of the large area over which the report extends:—

1.—General observations on the regulations for the discipline and working of fiery mines in England, and the mode of applying such regulations.
2.—Observations on the conditions under which gas is found in the collieries visited, and the accidents which its presence has produced.
3.—The general arrangement and organisation of the workings with regard to their ventilation.
4.—The mode of producing ventilation, its distribution, and the means of ensuring its efficiency.
5.—Working arrangements and supervision of the workmen.
6.—Lighting of the underground workings.
7.—The use of powder.
8.—Dust.
9.—Safety apparatus.

* The Representatives of the French Commission instructed to report on the Best Means to Prevent Explosions of Gas in Collieries.

There is also an Appendix, containing extracts from the Inspectors' Reports, the Special Rules of some districts, together with a table of explosions which have occurred since 1850 where more than six lives were lost.

The chapters are again divided and re-divided in a most bewildering way; for instance, Chapter III. is divided first into four sections :—

1.—Primary arrangements, with regard to the geological structure of the district and the local conditions attached to the leasing of the coal.

2.—Choice of site and extent and nature of surface plant.

3.—General mode of laying out the underground workings.

4.—Methods of working underground.

This fourth section is further divided under five heads :—

1.—Working by board and pillar.

2.—Working by pillar and long-wall, &c.

3.—Long-wall.

4.—Working thick coal.

5.—General considerations thereon.

And these are again divided into numerous paragraphs, such as "Principle of the method," "Working with pillars abandoned," &c., the last subject being treated under five different conditions, a minuteness of arrangement the translator has found somewhat tedious.

The entire report occupies 333 pages, rather less in size than the yearly Proceedings of the Institute. The first 40 pages are devoted to the English law and Government inspection.

The history of the various circumstances which led to the regulation of mines by the Legislature is an excellent summary of the question, beginning with the period before the passing of any Act, viz., before and up to 1842, the proceedings of the Association at Sunderland, the first trial of Safety-lamps, the first Commission on Mines in 1835, Lord Ashley's Commission on the employment of women and children in 1840, and the various Commissions and Acts of Parliament up to the last Act of 1872, and the present Royal Commission.

This is merely a matter of history and admits of no discussion; not so when the Commissioners go on to the application of the present law, where, under the head of "Extent of the Inspected Districts," and "The Powers and modes of procedure of the Inspectors," their observations are open to much criticism. For instance they are very much mistaken when they say in page 29 that "it would seem to be admitted in practice that every mode of working is permissible which is not positively and formally

prohibited by the law or the Special Rules, and the Inspectors, to use a stereotyped expression, are *without power* to interfere. Thus, we have found an Inspector admitting that he would be *without power* to interfere even should he find the air returns in a mine full of gas, because the first General Rule only requires that *an adequate amount of ventilation shall be constantly produced in every mine, to dilute and render harmless noxious gases* only in the *workings of such mine, and the travelling roads to and from such working places*, and says nothing about the air returns where there is no one passing."

Referring to complaints by workmen and their powers to inspect, the Commissioners say, in page 33, "this is a distinctive trait of the English system," and "may more or less remedy the insufficiency in numbers of the Inspectors."

After a short review of the subject of Special Rules and their difference in each district, although admitting that the law is by no means a dead letter, yet it is stated, in page 37, "that perhaps in many cases it would be found that there is a greater anxiety shown to comply with the letter of the law than to satisfy its spirit. . . . . All the reports the law requires are kept; but," they say, "one may be permitted to entertain a doubt as to the value of the entries so made." This, of course, is a most unwarranted assertion, based upon a perfectly gratuitous assumption, for surely a responsible official would not sign a report that all is safe unless he was perfectly convinced that it was so. Moreover, where are the facts which warrant this assertion?

Again, speaking of the difficulty of classifying mines, they say in page 38, "we ought not to quit this subject without making an observation on a point to which, in France, a certain importance has been attached. The difficulty encountered in defining a fiery mine in the text of any regulations, and in classifying mines according to the abundance of gas therein existing, is well known, and the provisions of the English law of 1872 have been cited, where, in three of the sections of General Rule 51, certain distinctions are made between mines where gas has or has not been found within twelve months (*see* sections Nos. 2 and 3), or within three months (section 8, sub-section *f*); but from all that we have seen and heard, we are convinced that these distinctions made in the law are purely theoretical, and that in reality no notice is taken of them in practice. The amount of inspection and the use of powder are settled once for all to suit the conditions and system peculiar to the mine, and in conformity with the General Rules; and as these rules are the same for a whole district, notwithstanding that

each particular mine may be more or less fiery, this distinction made by the law generally disappears. At the best, in some districts, there might be a dispute in the law courts after an accident, whether or not a contravention of the rules could be proved, and in consequence, criminal responsibility established. In conclusion, we think it would, under all circumstances, be taking a false step to appeal to the example of the English law, in any discussion upon this subject." These remarks are surely quite unfounded.

With a few comparative results given in table A, as to diminution of accidents for the years 1851 to 1878, the first chapter is brought to a close.

TABLE A.

	1851-1860, 10 years.	1861-1870, 10 years.	1873-1878, 6 years.
Total number of explosions causing death	82	56	41
Total number of deaths	244	226	263
Average deaths per accident	2·92	4·01	6·41
Total number of men employed (below and above) per explosion causing death	3,000	5,650	12,517
Total number of men employed (below and above) per death	1,008	1,408	2,984

Chapter II. gives the views of the Commissioners on the conditions in which gas is met with in certain English mines, and the causes of some of the accidents, which will meet with considerable dissent in this country.

They state "that the coal basins of South Wales, Lancashire, Yorkshire, and Durham are the most fiery, and are those in which the most numerous and the most deadly explosions occur. The basin of East Scotland and that of North Staffordshire might be added to this list, although it is pretty generally admitted that the reports of the Inspector indicate that the accidents which have occurred in the last-mentioned basin are more due to a vicious organisation of the workings than to the quantity of gas." So much for North Staffordshire. No wonder the Commissioners go on to state, "that for this reason we abstained from visiting North Staffordshire."

Again, they state in page 44 that "the most fatal accidents have generally been limited to particular districts where seams have been worked under the same given conditions, although in the same basin the same seam may be more or less fiery in proportion to the depth at

which it is worked. In Lancashire (page 45) it is especially remarked that "the abundance of gas in the same seam depends essentially upon the depth of the workings." This may be true; but when it is stated in the same page "that the only gassy pits in the North of England are those of great depth, such as from 180 to 300 fathoms," and that "the fiery nature of the mines depends on the depth of the workings," their remarks are open to grave criticism, since there are pits working at depths not exceeding 100 fathoms with equally as much gas, and often far more, than is met with in those worked at greater depths; besides, the deep pits in Northumberland are comparatively free from gas, so that depth is most decidedly not the governing factor in the case.

With regard to the characteristics of fiery seams in England, they state in page 46 that "an examination even rapid as our own of the various fiery districts in England gives strong reasons for thinking that the beds reputed to be most fiery have simply, what has happily been termed by the Belgian Gas Commission, *a normal discharge of gas* relatively feeble, ... excepting, perhaps, the Wigan 9 feet, the Aberdare 4 feet, the Barnsley and Silkstone, and the Black Vein in Monmouthshire." By this it is implied that a ventilation relatively feeble is sufficient to dilute the gas in the working places; but whilst comparing the ventilation with that of Belgium, they add (page 47):—"We do not lose sight of the fact in this comparison, that the average thickness of the Belgian seams is 23·6 to 27·5 inches, whilst in England it is very nearly, if not above, 59·1 inches, and in consequence the volume of air at equal velocities is double that in Belgium. Still there is no doubt that the English coal formations do in the fiery districts contain masses of gas, relatively considerable and abundant, which may come off in different ways while the seam is being worked, either from the seam itself without being brought in by the air current or from other sources. These outflows of gas may result from natural causes or from the method of working adopted."

Reference is then made to gas proceeding from seams outside of those being worked, and numerous instances are given.

EXCEPTIONAL OUTBURSTS.

Under this head the Commissioners remark (page 48) that "the English seem often to confound blowers with sudden outbursts," and add, "but the phenomena which they designate *sudden outbursts*, have not the essential characteristics of those which are now classed in Belgium, under the appellation *dégagements instantanés*, these latter

proceed from the virgin coal towards the open space left by the workings, . . . but the former always come from behind the face, generally from the thill and sometimes from the roof."

This appears to be hardly supported in fact; take for instance the outburst at Pelton, where 47,000 cubic feet of gas issued from the coal at a pressure of 912 pounds to the square inch (see Vol. III., pages 41 and 42* of the Transactions) in opposition to the statement. They then state "that although we have searched diligently we have never been able clearly to establish in England a case of true Belgian *dégagements instantanés*."

In speaking of *blowers* and comparing them with what is called *soufflards* in France, they say these present no great difference from what is usually known under this name, except that they are sometimes unusually powerful; for instance, at Outwood, in West Lancashire, at a depth of 984 feet in a stone drift, a blower was encountered of such magnitude as to suspend operations, and the gas was dammed off and taken to bank in pipes 2 inches diameter, where it burnt twelve months, with a flame 3 feet 6 inches high. They add also (page 51), "that it is frequently found that when a blower comes from a well-defined crack or fissure, large quantities of water are also met with," and then state that, "our view of the blower *(soufflard)* is, that the fracture through which it is discharged, whether a simple fissure or a fault, pre-existed, and the gas is discharged when the drifts reach it; whilst in the sudden outburst there is no pre-existing fracture, but one which takes place suddenly, and produces the discharge. The sudden outbursts from the roof and from the thill are very different, and have a distinctive character which is very remarkable."

SUDDEN OUTBURSTS FROM THE THILL.

"It is in the Barnsley and Silkstone seams in Yorkshire that these outbursts predominate in intensity and frequency" (page 52). "At a given moment, and with no warning, the top of a jud breaks, the thill immediately after rises, following a line of fracture more or less clear and parallel to the face of the place for a greater or less distance, and often extending to the workings adjacent."

For instance, "in 1876, at the New Oaks, to the dip of the Oaks, where the accident of 1866 occurred, an outburst took place in a rise long-wall in the Barnsley seam, ventilated by a current of 5 cubic mètres

* The insertion of the decimal point after the 7 and the preceding numbers in page 42, Vol. III., is a misprint; the addition should read 47,044.

per sec. (or 10,000 cubic feet per minute); and the returns were so loaded, that Mueseler lamps at the bottom of the upcast were extinguished in a current of 66 cubic métres per sec. (or 140,000 cubic feet per minute)."

"These outbursts may very well explain many of the accidents that occur, and it is no wonder that they are, under every circumstance, invoked by one side at the inquiries held before coroners, and more or less systematically denied by the other side. . . . . No one can deny the possibility of their occurrence; only it remains yet to be proved that any given accident is attributable to them."

"The engineers in Yorkshire and South Wales, the former especially, have often discussed what can be done to guard against these outbursts, which appear with every mode of working; they think that no amount of ventilation could dilute such masses of gas, and appear to have decided that they must submit and live with such an enemy, using only Mueseler and Stephenson's lamps, which go out in gas, abstaining as far as possible from using powder, and in enforcing a rigid dicipline."

They conclude with the following very severe remark (page 54):—"*It does not appear* to us, however, altogether proved, that the method of working and the general disposition of the pit, go for nothing in the question."

The Commissioners go on to state (page 54) that "we must at once point out that the fracture which gives passage to these outbursts is a consequence of the mode of working—in fact whatever method is employed, *long-wall* or *pillar and stall* pure or modified, the *principal of all English methods is, with rare exceptions, not to pack the space of the goaf or gob formed behind the face of the jud, unless in a very incomplete way*, and to allow the falling of the roof to take care of itself."

"Then if, as in Yorkshire, the thill is very stiff, a complete removal of the coal so effected inevitably determines the production of irregular weighing upon the thill, the effect of which must be to cause fracture along the face of the coal, which will be more severe and important, on the one side, as the thill is more stiff, and on the other as the roof breaks more irregularly. That this effect will be augmented by the pressure of the gas contained below is possible, . . . but if they worked on a system which does not excite the fracture of the thill, it might be hoped that the imprisoned gas below would not force itself out, and it may be asked whether, supposing a complete system of effective pack walling, carefully made with rubble brought from bank, and with the face (*étages*) methodically stepped at moderate distances, were

adopted—it would not regulate the pressure and effectually combat the breaking up of the thill? The question has never been examined from this point of view in England, where the working by packing with material brought down from the surface is at present altogether unknown."

The writer of this review thinks that for several reasons it will remain unknown:—1.—Because it is desirable that all imprisoned gas should get away as fast as possible instead of being kept at an intense pressure until some fault or fall causes it to break out in ungovernable quantities. 2.—Because the experience of all good pitmen goes to prove the absolute necessity of getting good clean falls which take all pressure off the face and close the goaf up solidly behind. Strange to say, the Commissioners in the very next page (56) of the report, praise the manager of the Wigan Coal Company for good practice in having sunk a bore-hole some 70 feet in the Silkstone seam, and so having successfully drained off a magazine of gas. (For full description of this, see page 23, Vol. XXV., of the Transactions.)

The Commissioners next say, in page 56, that sudden "*outbursts from the roof* are nothing else than quantities of gas which follow the falling in of the roof, or which escape from fissures in the roof without a fall, and do not present such marked features as the outburst from the thill. They occur behind the face in the goaf, or between the face and the goaf, and are facilitated by the nature of the roof and the numerous fractures, caused by the incomplete method of packing." To this it may be replied that if the gas is kept shut up in one place it will inevitably break out at some other. They state under the head of

ERUPTION OF GAS FROM OLD WORKINGS,

That "the discharge of gas from the goaf appears, from the tables annexed, to have been admitted after serious inquiry to have been the principal cause of accidents during the last ten years," and "the fear of gas from it is universal, and as far as we can judge is more pronounced where the packing *(remblai)* is most incomplete or is but tardily executed." This exactly proves that the sooner a good fall occurs the better. They go on to state that "there is always an important distinction to be made. The gas in the old workings may come from the normal discharge of the seam being worked, but it can also come from adjacent seams." The reviewer sees no reason why the former may not be effectually carried off as readily in England as in France. The Commissioners proceed to say (page 59), "However, we should remark that a number of English mines present circumstances much less favourable than

the bulk of those on the Continent for the carrying away of gas from the old workings. These workings in flat seams of a medium thickness, mined by pits in close contiguity and extending thousands of yards in every direction around them, such pits forming the only communication with the surface, evidently do not present conditions favourable to the ready escape of gas."

To this it may be answered that in the Durham coal-field, to which these remarks particularly apply, only one accident is recorded since 1870, in a Table of accidents given in Appendix 7, page 312, and that the immense volumes of air distributed, amounting, according to the Inspectors' Returns, to 250 cubic feet per person employed, fully compensate for the size of the workings; as to the contiguity of the shafts, so long as the gas is thoroughly diluted, how can it matter whether it passes through one mile of returns or two ?

ACCIDENTS FROM GAS IN ENGLAND.

Under this head the Commissioners remark (page 60) that "if certain accidents in England have had terrible proportions . . . it cannot be attributed exclusively to the relatively large number of men who may be employed in a mine, *i.e.* to what we call a concentration of work, but in part also to the conditions under which, and the mode by which, the workings are effected. Thus, as we shall hereafter have occasion to repeat, the districts into which it is necessary to divide the workings in a level seam ventilated by two contiguous pits to assure a sufficient current of air, are not so far independent of each other with respect to ventilation as that when an accident occurs in one it is without influence on the other. On the contrary, it is a chance, if an accident of any importance occurs in one district, that the air-crossings and stoppings are not blown out, and stop or upset all ventilation, not only in that district, but even in the neighbouring districts. Few men are burnt perhaps, but a large number are asphyxiated."

This, of course, is a large and serious question, which English viewers would do well to estimate at its full value; that shafts at each end of a Royalty will afford more chances of outlet than both in one place is clear; but, if the shafts were apart, a time will come when in working the pillars the connection between them must be cut off, and it is rarely that an explosion sufficient to affect the shafts leaves a chance for any one to escape; moreover, if the shafts were made much further apart, the already long period required to open out collieries on a large scale would be very seriously lengthened.

MANAGEMENT AND WORKING.

Under this head there is discussed:—"Coal-fields visited," "Inclination and thickness of coal beds," "Characteristics of the coal *in situ*," "Nature of adjacent rocks," "Geological accidents affecting the coal formations," "Concessions and mode of taking or leasing coal," "Extent of royalties," and "Rents," none of which subjects require notice; but under the head of "Consequences of the temporary concession," *i.e.* by lease, the Commissioners state in page 67 that "the multiplicity of landlords, and the obligation of paying a certain minimum fixed rent, increases in a disadvantageous manner the number of pits sunk in a given space, as we have seen at Blantyre; and the transitory character of the holding leads the mine owner to reduce to the lowest limit his first expenditure," and (page 68) "leads him only to work the cheapest and best seams," leaving others "which serve as magazines of gas, and which any accident such as a fall of roof, might any moment place in communication with the works," and "this is one incontestable cause of the importance of explosions which occur in England."

But who is to decide whether a seam should be worked or not? Clearly Government should not have the power to insist on working a ruinous mine.

Again, the Commissioners say, in page 69, "the position of the shafts in the royalty, owing to the easy inclination and the regularity of the coal formation, is almost a matter of indifference, as the same facilities for working the coal may be found in any part of the royalty, and the English thus constantly use mechanical haulage and pumping machinery at very great distances to the dip for both coal and water. . . . . Everything is thus made subservient to convenience on the surface, which has undoubtedly its importance, but which should not make managers forget considerations affecting the interior workings, especially those having an influence on personal security. . . . . Hence the immense development of wagonways and ventilation, which is one of the characteristics of English mines."

CAUSES OF THE LARGE EXTENSION OF UNDERGROUND WORKS COMPRISED BY EACH WINNING.

Under this head the Commissioners go on to state (page 71) "This mode of holding mineral property (by lease) tends to make a colliery owner only a passing tenant. . . . . He thus reduces as far as possible all permanent erections which belong to the freehold, and, instead of sinking more pits, employs more underground machinery, which remains the property of the lessee."

English engineers will see here much to dispute. No doubt there are sometimes cases where the position of the pit affects the "residential interests" of the landlord, but with that exception shafts are always placed where the coal can be worked to the greatest advantage in all respects. The disadvantages of having the shafts both in one place—of the long air ways and weak points of air crossings are again alluded to; but after referring to places arranged and ventilated on the principles they so strongly advocate, the Commissioners are obliged to admit that these have not been more free from accidents than the others.

Next follow discussions on arrangements to facilitate the inlet and outlet of the air:—Furnace pits, surface arrangements at upcast pits, pits with ventilators, shapes and sizes of shafts, shaft guides, stone drifts, etc., finishing on page 95 with the statement that Government Inspectors do not consider it their duty to interfere in the general arrangements and laying out of pits.

INTERIOR ARRANGEMENTS.

This division treats of working several seams, average depth of pits, annual average, increase of depth, various methods of ventilation, arrangements at pit bottoms, stoppings, separation doors "which are never guarded," regulators, brattice cloth, air crossings, none of which require attention except, perhaps, the Barrel Crossing at Llwynpia, in South Wales, and that at Celynen (Plate I., Figs. 1 and 2), made entirely above the seam, with such a mass of rock or masonry intervening as to make them secure against any explosion; general arrangements of work; and some particulars relating to the Lundhill workings, with the mode of working long-wall pillars (*massifs longs*).

Next, the plan of Eppleton workings is described, including both board and pillar and long-wall. The Commissioners add (page 123): This plan shows in a striking manner how capriciously the old goafs are distributed and what traps they are. Then they discuss winning drifts, general distribution of air at each mouthing (*étage*) ordinary drifts, and space for air in workings, where they observe (page 127) that "generally we may say that in the arrangement of drifts which distribute the air the section of the air courses is superior to that in those on the Continent," but owing to the absence of stone packing the air is not carried forward so well, which reduces the air at the face very much.

METHODS OF WORKING.

The methods of working by board and pillar, pillar and stall (Lancashire), double stall (South Wales), and long-wall (*longues tailles*) are next

described. Of the general modes of pillar workings given it is not necessary to say much except that they seem to have been very unhappy in the examples taken; for instance, that of Allanshaw, in Scotland, illustrated in Plate II., Fig. 2. It is quite clear that in order to get No. 2 in the pillar when the lift No. 1 in the upper pillar is worked off below they will have to skirt through the goaf edge, and have their men daily getting into a more dangerous position from the goaf following them.

VENTILATION OF THE BROKEN.

This is explained by the sketches given; take, for instance, that of Haswell, Plate III., Fig. 1, where they say (page 146): "The air is carried up the bottom of the first jud by the drifts made in the first working place well enough, but on leaving this it is either lost in the goaf, or it passes as directly as possible to the air returns, arriving in very small quantities in the face of the jud, whence it passes with great difficulty to the following jud, because there is no proper packing *(remblai)* to reserve for it a passage along the coal side, although there is generally a row of props, 12 to 18 inches from the side, to keep up the top." Plate IV. shows the mode of working and ventilation at Eppleton, also the propping and packing. The Commissioners adding (page 148), that in "working the broken the air goes much as it likes." Under the head of

SEPARATION OF BROKEN DISTRICTS,

It is further stated that: "The omission of regular packing causes each district of broken to become a vast reservoir, in which the roof, irregularly fallen, remains hanging over great spaces. To reduce as much as possible the dangers from a fall of stone which might drive out the gas from these vacant spaces, the English attempt to isolate the goaf by stone stoppings."

Then follows a description of working in pillar and stall (page 149).

MODE OF SETTING OUT THE FACE.

"This consists in driving two drifts from the main wagonway horizontally 7 to 10 feet wide, separated by pillars 12 to 40 yards thick, according as it is intended to use the pillars only to protect the road or to form the first pillar in the long-wall. Sometimes, as at Pendlebury, the pillars are only 80 yards wide; the working is by single drifts ventilated with brick brattice, connected by cross galleries whenever the ventilation requires it. When the galleries have reached the limit

intended, two cross-headings are made, separated by a pillar 33 to 45 yards wide, intended to serve for the working of the upper pillar, and after the ventilation has been assured by this they commence working the broken."

"This broken working is made in several ways—by successive contiguous rising juds sometimes cutting up the large pillars by drifts parallel to the exploring drifts. . . . . Generally these juds are arranged in steps, with the highest one nearer the main wagonway than that below."

"Sometimes, as at Lundhill, where they have a seam about 7 feet thick, with a regular inclination of 30 inches to the yard, all the pillars, in a block (*massif*), three to five according to its size, are worked at the same time, and then the juds," as shown in Plate III., Fig. 2. "At other times, as at Pendlebury Doe Mines, in a seam 5 feet thick, with an inclination of 10 inches to the yard, they reduce the width of the blocks to 80 yards. They are then cut up in returning to the main wagonway by successive contiguous rising juds," as shown in Plate V., Fig. 1.

Plate V., Fig. 2, shows the mode of working in the "Ram's Mine" Seam, Pendlebury, by contiguous blocks simultaneously rising in steps, each jud having the way laid through the goaf and supported by stone packing.

Plate VI., Fig. 1, shows the broken workings at Lundhill, with the propping and packing most common in England.

VENTILATION OF LONG-WALL IN COURSE OF WORKING.

Under this head the Commissioners remark (page 156) that "the mode of ventilating the broken workings is sufficiently shown by arrows upon the plates. We think it right to state that very often the ventilation is not better than in the broken of the board and pillar system—first, because in the long-wall system a great quantity of air is lost by the doors, brattice, and stoppings, fixed or movable, which are multiplied to infinity; and also because the air, when it arrives at the extremity of the drift, is very insufficiently conducted to the face. The packing in most cases is simply produced by the fall of the roof, which is left to itself, allowing the air every opportunity of escaping by the shortest route."

The system of working blocks by following juds separated by an abandoned pillar, or the Wicket System of North Wales, Plate VII., is then described (page 159): "This is applied to seams from 6 to 10 feet thick, but little inclined, and only slightly fiery. The ventilation of the jud is made good only by a very incomplete packing up the middle, made from the

impurities of the seam and small coal. These juds form, in fact, *culs-de-sac* with regard to the air, and may be said to be only ventilated by diffusion; this causes the Inspectors often to report collieries in their districts which are insufficiently ventilated."

Plate VI., Fig. 2, shows a mode of working by Single Stall, by following juds separated by pillars of the same width, which are removed on returning towards the exploring drifts. Sometimes, when the top is good, there is a double arrangement of exploring drifts, with the juds on both sides, as shown, and the ventilation is of the same character.

With regard to Double Stall, the Commissioners remark (page 164) that "in all these systems it may happen that the ventilation is very poor, because the packing being very incomplete there is no assured circulation of air in the face where the air return is neither maintained nor watched, and to remedy this in all well-conducted mines they have substituted the double for the single stall. This modification consists in giving to the jud a double width, and in maintaining two tramway roads laid up both sides, kept up by careful timbering separated by packing of a very incomplete character made of small coal, the air passing up one wagonway and down the other. . . . . When the jud, from 12 to 24 yards wide, has got half-way up to the cross drifts, the hewers divide into two parties, and each brings back half the width of the coal left between the two juds." See Plate VIII. and Plate IX., Figs. 1 and 2.

The Commissioners add in page 166 that "In Yorkshire, in what is called the Bank System, the pillars are 200 yards wide and 1,100 long. The first working consists of double drifts, and the juds are worked back to the main wagonway by double lifts 18 yards wide, with pillars between of the same width, won, worked, and ventilated exactly the same as double stalls in South Wales; the only difference in the working places is that they always systematically pass a little air over the goaf by making a small opening in the pack wall which conducts the air to the face of the jud."

VENTILATION OF SINGLE OR DOUBLE STALL.

In page 167 they add "Whatever precautions are taken to ventilate either single or double stall in the different varieties of pillar and stall working that we have seen, this method of working the broken by separate juds, separated by big pillars, has, from a ventilation point of view, the inconvenience of forming in the juds at each side of the exploring drifts *culs-de-sac*, in which the ventilation is always uncertain,

notwithstanding the doors, brattices, and stoppings, the multiplicity of which is shown by the preceding plates."

The translator of these remarks entirely endorses them, and further thinks that the small detached goaf prevents that steady uniform breaking down of the top, which is one of the first objects in good broken working, and leads to a great waste of coal.

THE LONG-WALL SYSTEM.

This is divided generally as "working outwards," and "working home," and the examples are confined to a few special systems.

GENERAL DESCRIPTION.

Working outwards (Plate X., Fig. 1).—The Commissioners state that this is chiefly developed in Yorkshire, Nottingham, and the Midlands, and is conducted without previous winning out, starting from the double main wagonways.

These faces are driven forward, removing the whole of the coal with drifts kept open through the goaf for travelling and ventilation by pack walls. This method requires either that there should be sufficient refuse from the seam or suitable stone from the falls of the top to supply material for pack walls.

Working home (Plate X., Fig. 2) is the reverse of this system, and is adopted where suitable packing is not met with; drifts are then made enclosing suitable areas, and the walls work backward, without having to maintain any goaf roads.

The length of each jud face varies from 5 yards to 30 yards, as also does the entire length of wall. In Nottinghamshire they are about 5,000 yards long; in Lancashire, at the Wigan Coal Company's collieries, they are about 2,700 yards; and in Yorkshire from 900 yards to 1,200 yards: they are generally parallel or perpendicular to the cleavage, and when the tram roads have gone as far as to be troublesome to maintain, they are cut off by cross-roads, supported by packing or dry walling. Generally the top is supported by two or three ranges of props, 20 inches or 3 feet apart, according to the nature of the roof, and leaving a space of from 4 to 5½ feet clear from the face. The back range is then moved forward to the front, allowing the top to fall, constituting a goaf, more or less perfect, according as it falls more or less completely; and when the roof is hard these props are substituted by chocks (Plate XI., Fig. 2). See pages 169 and 179.

"At Wain Lynd, in Wales, where they work the three-quarter seam about 3 feet 4 inches thick, with an inclination of 2 inches to the

yard, the air goes to the face by a main road at the low end of each group of headways, follows the face for from 250 to 300 yards almost in a straight line, and comes back to the return by a drift specially driven in a seam about 20 feet above that working. . . . But in whatever mode these long walls are conducted, we may say that, in a general way, they are better ventilated than the board and pillar places," pages 182 and 185; and in page 185 they add that "The only drawback to this system is that when the stone does not fall freely so as to give plenty of packing, the goaf leaves spaces for gas to collect, as dangerous as in other methods, and leaves the ventilation defective." In order to counteract and "maintain the incontestable superiority of long-wall, packing should be brought from the outside; and this the great competition in English collieries does not permit, as a few pence more or less in the cost of working would absorb all the profit they can make, and increase the loss many are even now experiencing."

WORKING THE THICK COAL IN SOUTH STAFFORDSHIRE.

The description of this system of mining, though very ably given, is not of sufficient general interest to warrant the lengthy notice which would be necessary to make it intelligible; but of the ventilation we learn in page 193 that, "whilst it is very good in the principal galleries, it is almost nothing (*presque nul*) in the winning out drifts where the air simply penetrates by diffusion." They finish up by stating that, by this method of working, one-half of the coal is completely got, the other half is got badly enough; abandoning juds 8 yards square in each of the 18 yard square juds at the sides, of which one-third is generally lost.

The Commissioners then proceed to make

GENERAL REMARKS ON THE METHODS OF WORKING IN ENGLAND,

and state (page 194 and following pages) what they consider to be the essential characteristics of the English systems.

1st.—"The great extent of workings in each seam—which always constitute distinct flats or levels (*étages*), only communicating with the surface by the two pits alone."

The reply to these remarks is briefly, that they are unreal and imaginary. Some of them have just so much foundation in fact as to prevent it being said that they are in every sense untrue. The expression "two pits alone," seems to imply that it is not only a characteristic of, but a fault in the English system.

2nd.—"The arrangement of working places in each seam in distinct districts scattered in every sense, and constituting so many *culs-de-sac*, in which the air enters and leaves by two parallel drifts always very close together."

In this sense every mine in the world is a *cul-de-sac*.

3rd.—"In whatever order the districts are arranged, we find them always subordinate to the rapidity of coal getting and the quantity of the output, an arrangement which, very often, causes the construction of the two main intake and return airways, which pass great distances between or through old workings, beyond which there exist districts in full work, which form at the extremity of the main roads *culs-de-sac*, which the least disturbance affecting these roads insulates completely."

It may be admitted that it is desirable to avoid detached goaves, but in the long-wall system, so highly spoken of by these same gentlemen, the essential principal is to have the roads entirely through goaves.

4.—"The absence of a sufficient quantity of packing, carefully placed in suitable situations to lessen the dangers presented by these old workings, which the general fracture of the rocks or any other cause may constantly supply with gas. These magazines of gas, which occasionally occupy a space of nearly 600 acres, may, by the slightest accident, be put in communication with main roads which traverse them and carry into the working face quantities of gas, which, even if not in themselves very considerable, might suddenly render a current of air explosive, that might have been before considered as sufficiently free from gas to be applied to keep up the combustion of the furnace."

If this refers to board and pillar collieries the answer is that the roads are always protected by two or more solid pillars of coal with brick stoppings stowed close, infinitely better than any pack-walls however built, and no fracture of the rocks can drive gas into the intakes; although it might be driven into the returns where it could do no harm.

5th.—"The very rapid working of seams of moderate thickness, which tends to cause sudden dislocations of the adjacent rocks, such dislocations being often accompanied by considerable discharges of gas."

Rapidity of working is a comparative term; if the supply of air and other conditions are commensurate with the rapidity of the workings, it is no greater source of danger than is that of speed in express trains as compared with slow ones.

6th.—"Hewing, often effected with powder without much precaution."

This certainly does not apply to the North of England where the regulations with regard to the use of powder are carried out in the strictest manner.

7th.—"The almost invariable practice of allowing horses to go into the face, a custom which exposes the numerous doors used in England to be badly closed and necessitates the employment below of two or three hundred horses in large mines."

If horses were not so largely used, manual labour would be very greatly increased, and the risk to human life would be much greater than at present.

8th.—"The support (*soutènement*) of the workings, always of a temporary character, which in all systems, except in long-wall, is often insufficient to ensure the passage of the air from one place to another."

Timbering as practised here needs no justification. The deputies have as much timber as they or the overman consider necessary; the managers see that it is used properly, and the passage of air is sufficient to ensure that no gas is visible where men are working; there exists a constant pressure of air from one end of the pillar workings to the other, which Messrs. Pernolet and Aquillon seem unable practically to appreciate.

9th.—"The multiplicity of brattice-cloths, doors, stoppings, and crossings of air, joined with the absence of continuous packing to guide the air to the face, causes a great loss through leakage of incoming air, so that, in spite of the enormous quantities entering, it often arrives at the face in smaller quantities than in Belgium, where there is an entry of only 84,000 cubic feet of air per minute in the largest collieries."

There is no doubt a great surplus of air entering a mine over what goes actually round the face, but which, if forced round the face, would render the places quite unfit and impossible to work in. Hewers cannot and will not work with air blowing cold upon them.

With regard to the intervention of Government in the organisation and arrangement of underground workings, the Commissioners state in page 198 that

"Although all Inspectors consider the method which is adopted for laying out and conducting the mine as an essential feature with regard to the security of the workmen, and although some of them have told us that they find it safer to work with open lamps and use powder in a seam worked under a good method than with safety-lamps and no powder in a seam badly managed, all Inspectors consider that so long as any

system has not caused accidents, they have no advice to submit on the subject, and have even said that they believe in such a case they have no right to interfere."

"The Inspectors consider they must allow colliery owners (*exploitants*) to arrange their works as they see fit, and, in fact, do not interfere in questions in many respects so delicate."

Inspectors have full power to prevent any dangerous practice, but Englishmen do not consult Government as an authority from whom they are to be instructed in the full details of the management of their work.

VENTILATION AND VENTILATING APPLIANCES.

Under this head there is not much calling for special notice. The various systems of creating ventilation by furnace and the different types of fans are briefly noticed.

Useful drawings of the large furnaces at Lundhill and Eppleton are given, and the reasons for the preference still shown for furnaces in deep pits are carefully explained.

Of the ventilators, the Guibal receives the highest approval, although the Commissioners admit the ease and cheapness with which the Schiele can be applied, and give tables of experiments in which this fan has excelled all others in useful effect.

The remarks on depression effected (or water-gauge) in relation to speed of periphery in rotatory machines are interesting, but this relationship, which has long been known and treated by the Institute, is spoken of as quite a new idea.

They say in a note at the bottom of page 208, that "although the notion of the *rendement manométrique* of a ventilator is well known to readers of the excellent work of M. Murgue, it is as well to reproduce it here." M. Murgue showed that for every ventilator, the effect of which is to create a depression, "there is a certain 'theoretical depression' which a ventilator of that diameter turning at the same speed can only produce, if perfect in the absolute sense of the word. This is $H=\frac{u^2}{g}$, u being the speed of the periphery. The depression h which is given by a machine can then never be more than a fraction of H, viz., K H of the theoretical depression, this fraction K being the useful effect of the apparatus (*rendement manométrique*)."

The actual results of several typical ventilators is then reviewed and tested by the standard of the *rendement manométrique théorique*.

Referring to the Guibal, the fact that in England we have some much larger than on the Continent, viz., 45 feet (14·02 M.), is deprived of considerable importance, because (at Abram, in West Lancashire, for instance), the normal speed is 46 revolutions, "but it might certainly go at much higher speeds."

This the translator thinks is wrong; the great drawback to the large ventilators is that they cannot, and never do, go at a greater speed than that mentioned. An interesting table of the results of 29 ventilators is given, in which it is only necessary to draw attention to the column called "Equivalent Orifice," of which the following explanation is given (page 220):—

"At any given mine, in producing a depression H, at the mouth of the upcast, it is not possible to pass more than a given volume of air V. The mine in question, considered with regard to the resistance which it opposes to the passage of air, can be assimilated to an orifice *a* in a thin partition, through which would pass the volume of air V. If the difference of the pressures at the two sides of the orifice were precisely equal to H, *a* will be the "*orifice équivalent*" of the mine under consideration. It will be at once seen that the section of this orifice in the *vena contracta* is the measure of the resistance offered by the mine given in a very simple manner."

The translator finds the formula given, $a = \frac{0{\cdot}38\ V}{\sqrt{H}}$, is not quite accurate, since it is based upon the weight of air being 1·20 kil. per cubic metre. But by taking air as 820 times lighter than water the following adaptation to English measurements will give the area of equivalent orifice in square feet:—

$$a = \frac{{\cdot}2\ V}{\sqrt{H}}$$

The result of this test enables them to show that, as a rule, English mines are large, and some very large.

VOLUMES OF AIR IN MINES.

Enormous volumes, such as 360,000 cubic feet per minute, are the result of the large "equivalent orifice" and heavy water-gauge, but this, although three or four times greater than any met with on the Continent, loses much of its importance "when we go to the bottom of things."

Thus, "taking 18 mines, we find an average of 400 cubic feet per minute per hewer per shift employed (*ouvrier du poste*); and an average of 210 cubic feet per ton worked in 24 mines" (page 224).

These figures are practically the same as those relating to Belgium in respect of tons, but double as to workmen. But the Commissioners say (page 225), "We must not lose sight of the fact that the useful effect of the miner is also double. Therefore, the figures are relatively comparable with those on the Continent; and there remains to England only the merit of concentration rendered easy by the division of air currents, which the nature of the stratification permits, but which is obtained, perhaps, at the cost of security."

SUB-DIVISION OF AIR.

"The superiority of England disappears still further when we look into the way these enormous volumes are divided and applied to dilute gas." From the daily registers we learn that in many pits, from 25 to 50 per cent. of the air goes down one pit and up the other without penetrating the workings, being used for stables, boilers, etc., when not lost by simple leakages in doors, stoppings, and crossings, and such air as does go in-bye has losses of its own, often caused by the intakes and returns running parallel to each other for many thousands of yards, only separated by stoppages of a very doubtful tightness." As an example of this they cite the

DIVISION OF AIR AT EPPLETON,

Where the tables given show that 54 per cent. only of the total air supply is used in the workings, the remaining 46 per cent. being used in the various requirements about the pit bottom, and the general conclusion is that "although at the shaft bottoms they have in England enormous volumes of air, that really and in fact there is rather less, than more, usefully applied in the working places than is found in Belgium and France, and that the circulation of air in the workings is conducted under circumstances much less favourable to the removal of gas than in those countries." (See page 229.)

The same views are repeated in the next chapter on the

DISTRIBUTION OF AIR,

Where the insecurity arising from air crossings, doors, etc., and the *cul-de-sac* nature of the systems is still further illustrated by short references to the various figures; but as all show the same determination to see nothing right, it is needless to repeat them.

INFLUENCE OF BAROMETRIC VARIATION.

There is here another instance of the perverse way in which everything done in England is looked at. With reference to extra precautions

when the barometer falls, they say :—" We were nowhere told of such special precautions," and "if anyone did sometimes speak of pushing the fires and the speed of the ventilators, it was in such terms that it was very problematical if any such precautions were ever really taken."

Again, there is a glaring instance of what really amounts to unfairness in their treatment of facts, when in speaking of the daily records of the various officers, it is stated, in pages 239 and 240 :—"It may be permitted to us to doubt the value of the observations thus made, the more so as most of the instruments employed are of the most simple and elementary description. They appear to have been used rather to satisfy the law than to attain any immediate object." And this same disregard of facts is repeated several times in the next chapter, on

WORKING ARRANGEMENTS AND SUPERINTENDENCE.

Where, in speaking of these same reports, it is stated that :—"They simply satisfy the literal requirements of the law." The remainder of this chapter is descriptive of the various officials.

UNDERGROUND LIGHTING.

This division mostly treats of the various types of lamps; and it is stated that (page 266) "for the rest, much as they have learnt by experience in England of the defects of certain lamps, they give little apparent thought in practice (up to the present time at least) as to the best kind of lamp to be systematically adopted."

WORK WITH POWDER.

The recital of conditions and customs in respect to the use of powder does not require notice beyond the manner in which it is spoken of generally. "We may say that in England, as a matter of principle, they restrict very slightly the use of powder in the working of fiery mines."

As to precautionary measures in the use of powder, they say, in page 276, that:—"In this, as in many other cases, the Inspectors leave owners and managers to act on their own responsibility within very wide limits, and they always apply the law with a very free interpretation."

But speaking of an instance in which an Inspector having insisted on the disuse of powder and got a verdict by an umpire in his favour, it is satisfactory to find the following admission (page 278) :—"The Inspectors may also evidently appeal to this power whenever anything appears to them *to threaten or tend to threaten the safety of persons employed in a mine.*"

DUST.

Under this head there is, in the first place, a short reference to the experiments made on this subject in England, and a good sketch of the arrangements made by Mr. Galloway, to carry out his experiments. The Commissioners add (page 285) that "the dust question remains in dispute as in France. The general and most common opinion is that dust may in certain cases add its effect to that of gas, but its additive effect has hitherto been in proportion to the determining cause, which is always and exclusively gas. This reduces in a marked manner the importance of dust." They add that, "the dust question has attracted much attention on the occasion of the late accident at Seaham. . . . . The mine being very dry, gassy, and hot, and the coal very inflammable, we endeavoured to see whether there had been any burning of dust. In no part, however, have we seen any incrustation of coke, but in many parts the timber and sides were covered with soot, notably at one point where the wood, moreover, presented traces of burning."

"These were indeed appearances which, according to the theory of Mr. Galloway, sufficed to affirm the action of dust. However, while the No. 3 district in the Maudlin is still closed, all the questions raised by this accident will remain very doubtful."

PRECAUTIONS AGAINST DUST.

"With the opinions which still prevail on this subject, we can understand that few people think it necessary to have recourse to watering. . . . . We have only seen it practised in the Dinas and Llwynpia mines. The former managed by Mr. W. Galloway himself," where they have framed a set of rules which define what is to be done.

This completes the Report, with the exception of a few pages of statistics of accidents and copies of Special Rules. It now remains for the mining engineers of this country carefully to consider the same and glean from it all the information that it is capable of affording.

The PRESIDENT said, they were very much indebted to Mr. Steavenson for bringing this matter so fully before them. It was often said that much good arose from sometimes "seeing ourselves as others see us," and he hoped that this would be the case now, and that good would result from the not over flattering remarks of these French gentlemen. But in considering this report a variety of things must be taken into consideration

and more especially must they remember how differently things were conducted by the two nations. It was still probable that there were points in connection with the strictures contained in the report, on which the judgment and observations of independent parties, coming from a different country, and entirely unaffected by local prejudices, might be of service to Englishmen; and, if this enabled Englishmen to pick out a weak point in their system, they would have reason to be thankful for this report, although the French Commissioners might be too severe upon them. The paper would be printed and issued, and it would not be necessary to discuss it fully at this meeting.

Mr. D. P. Morison hoped the discussion would be adjourned. He thought that some of the remarks upon ventilation were founded on error, and he hoped some member who had given attention to this subject would point out these inconsistencies and errors at the next meeting. With regard to the question of ventilation, as between the long-wall and pillar and stall systems, the whole of the experiments he had made tended conclusively to prove that the friction upon ventilation by the long-wall was between three and four times as great as it was in the board and pillar system of the North of England.

Mr. J. Willis said, it seemed to him that the whole report was got up on the principle of showing the superiority of mining in France to what it was in England, rather than, as its title would indicate, a Report upon Mines in England. The Commissioners had made many remarks about the inspection of mines which seemed to prove that however diligently they might have observed while here, they had not had time to master the subject thoroughly. If the discussion of this report was left over till a future meeting he hoped it would be then temperately dealt with, and not have attached to it that importance which, to his mind, it did not deserve.

Mr. J. Daglish said, that in discussing a question of this kind, especially in relation to the duties of the Inspectors, it should be borne in mind that the minerals in other countries of Europe belonged to the governments, and therefore that the inspection is specially directed to the working of the coal to the greatest possible commercial benefit of the Government, whereas this did not form any part of the duty of Inspectors in England. In reference to the working of upper seams first, it would hardly do for the proprietors in England not to be allowed to work their own coal in the way they thought best. It was impossible that any gentlemen, however able, could, in passing through a large country and visiting a few mines, arrive at even a very general idea of the details of practice followed in

various districts. The use of powder in mines in this country received the greatest consideration, and every possible care is taken against accident; and with regard to dust, the greatest precautions are taken to water the ways, &c., and stringent regulations issued; but, because these French gentlemen did not hear of them, they reported that these things were not cared about in England.

Mr. A. L. STEAVENSON said, that the report of the two French gentlemen might be called a State document, being the report presented to the French Government by a Commission similar to a Royal Commission in this country, and it was desirable, therefore, that attention should be called to it; but in all other respects, there was nothing in it to which they should attach much importance.

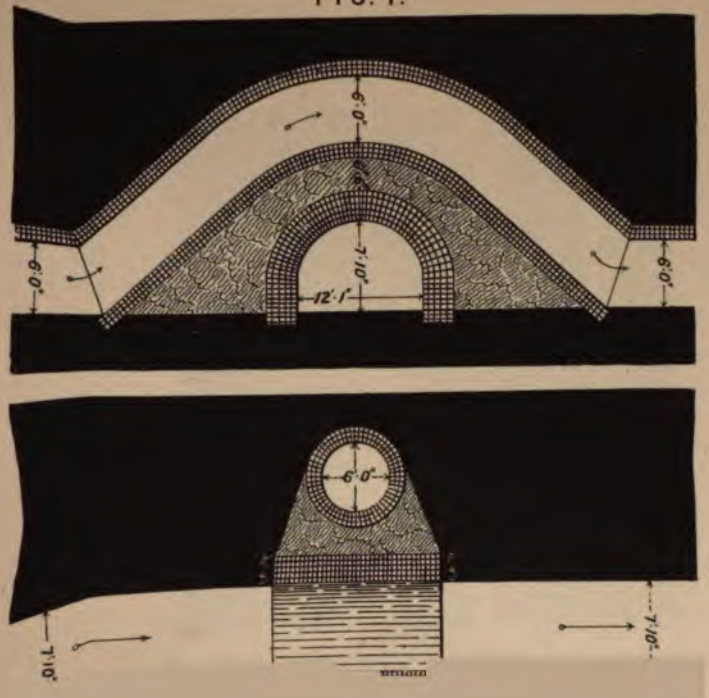
Mr. E. F. BOYD said, it seemed to him that the question was of importance to the members of the Institute, inasmuch as they ought not to allow a report so prejudicial to the state of things in England to go forth without contravening the portions which were incorrect.

On the motion of the PRESIDENT, seconded by Mr. E. F. BOYD, a unanimous vote of thanks was awarded to Mr. Steavenson for his communication, and the meeting separated with the understanding that an early meeting should be fixed for its discussion.

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquallon upon the Working and Regulation of Fiery Mines in England.

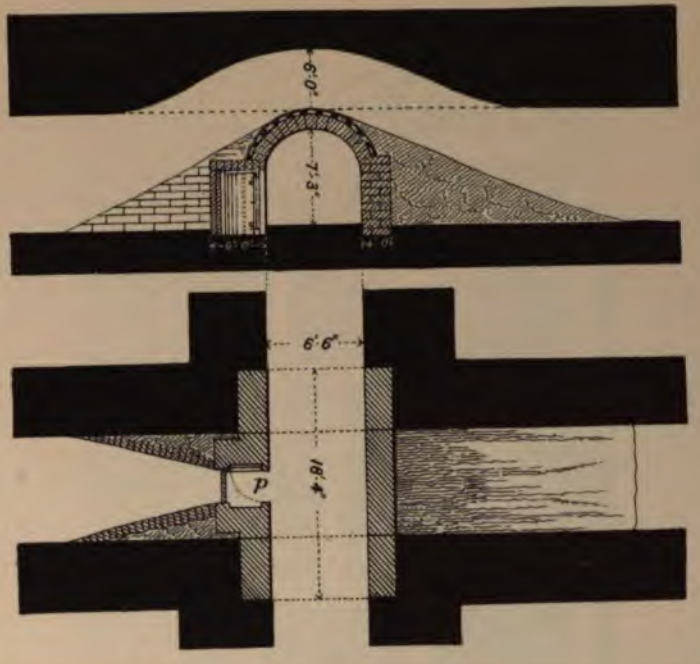
Air Crossings at Llwynpia South Wales.

Fig. 1.



Air Crossings at Celynen.

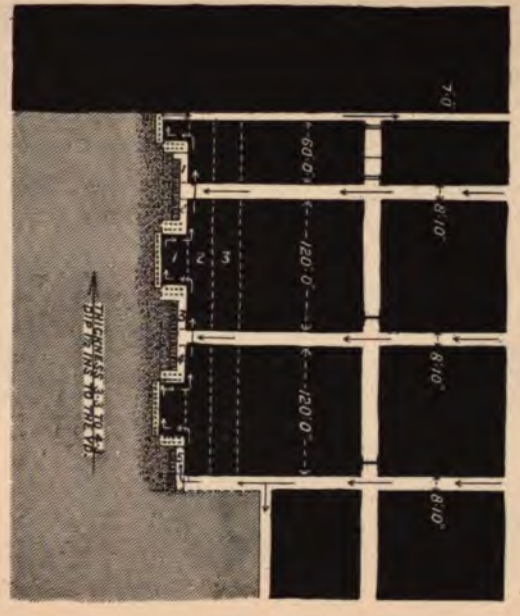
Fig. 2.



To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquallon upon the Working and Regulation of Fiery Mines in England.

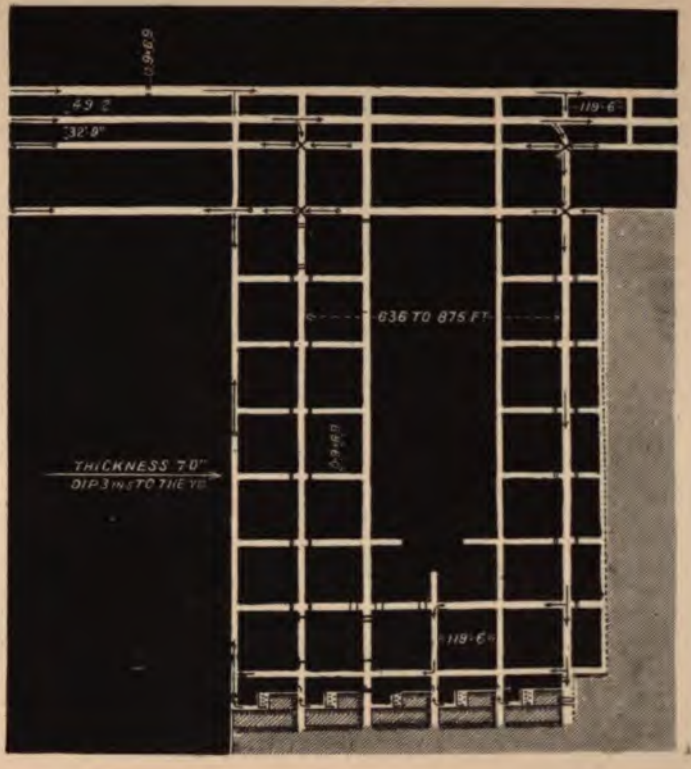
Arrangement of the Broken Workings. at Haswell.

Fig. 1.



Mode of Working the Broken at Lundhill.

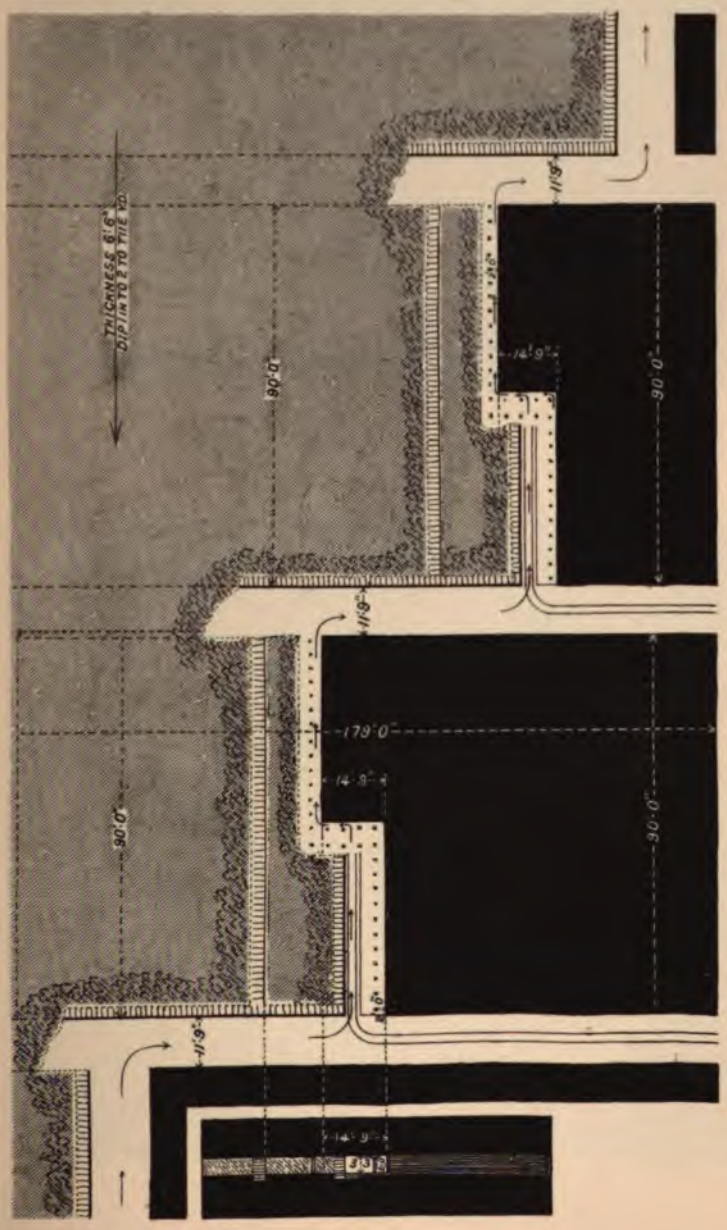
Fig. 2.



Andrew Reid, Newcastle

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquillon upon the Working and Regulation of Fiery Mines in England.

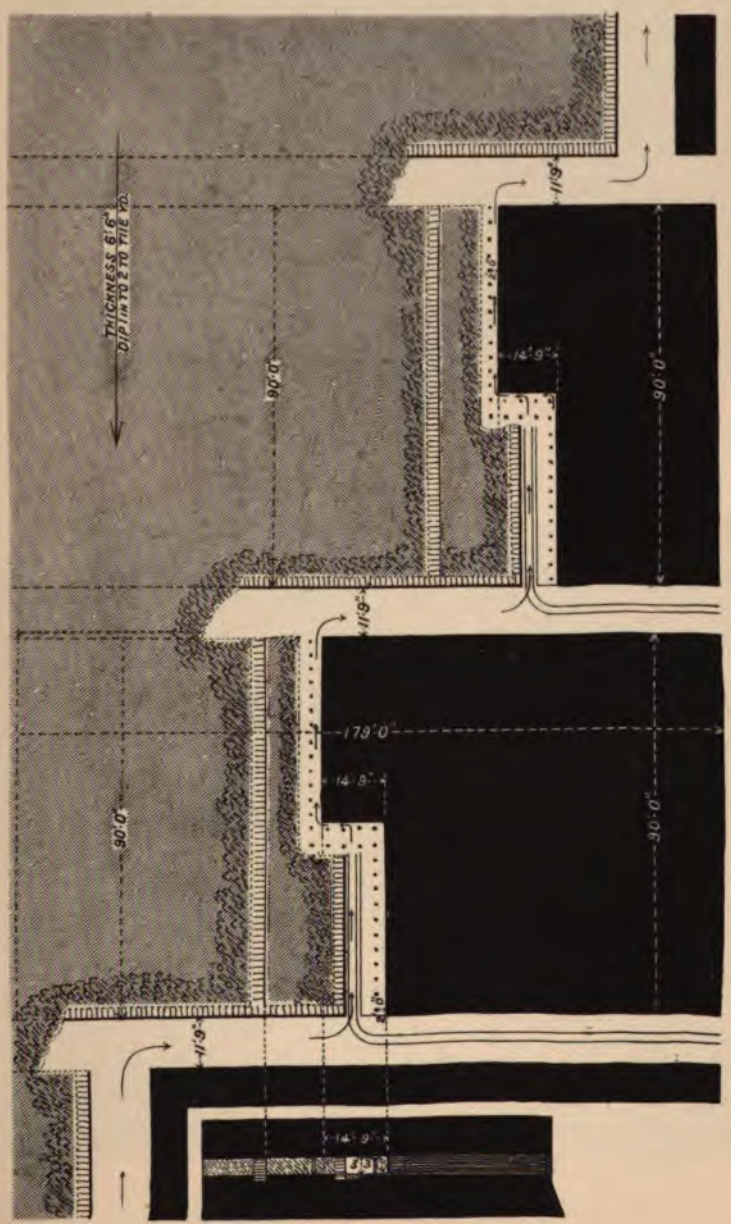
Arrangement of the broken workings of pannel at Eppleton.



Andrew Reid, Newc.

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquilon upon the Working and Regulation of Fiery Mines in England.

Arrangement of the broken workings of pannel at Eppleton.

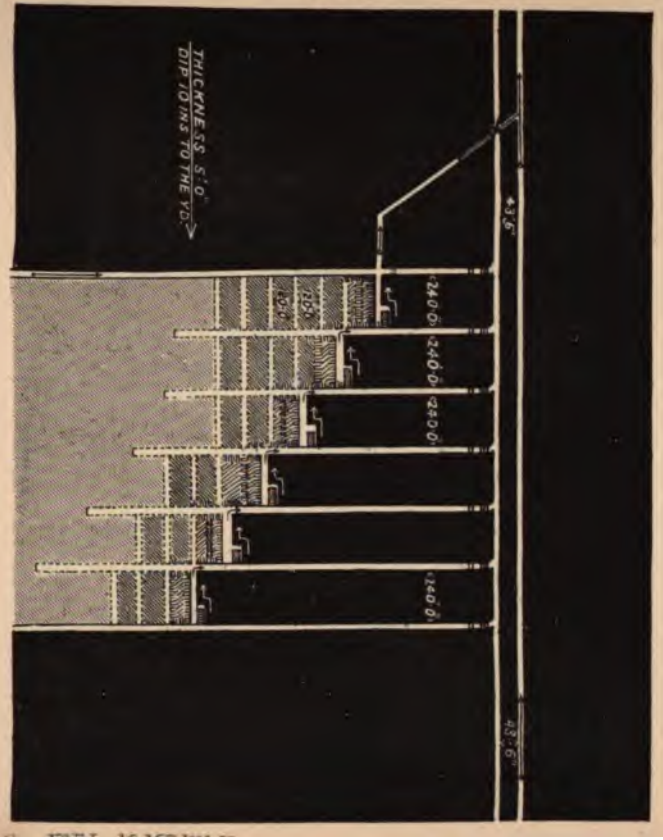


Andrew Reid.

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquillon upon the Working and Regulation of Fiery Mines in England.

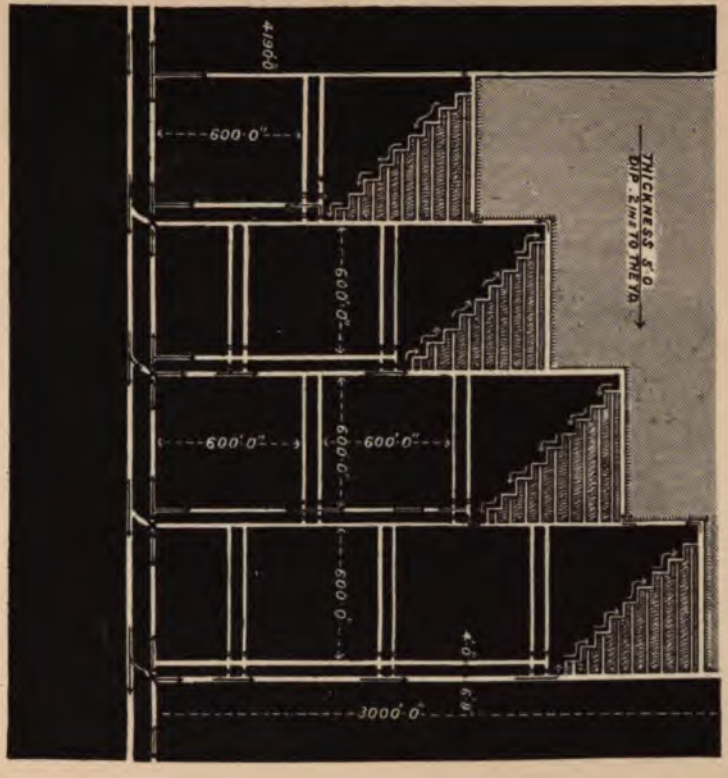
MODE OF WORKING THE BROKEN IN THE DOE MINE SEAM, PENDLEBURY.

FIG. 1.



MODE OF WORKING THE BROKEN IN THE RAMS MINE SEAM, PENDLEBURY.

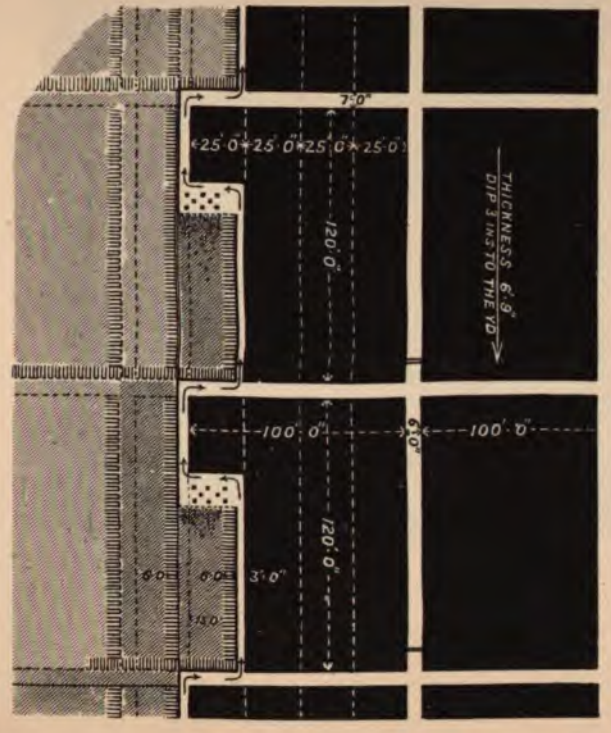
FIG. 2.



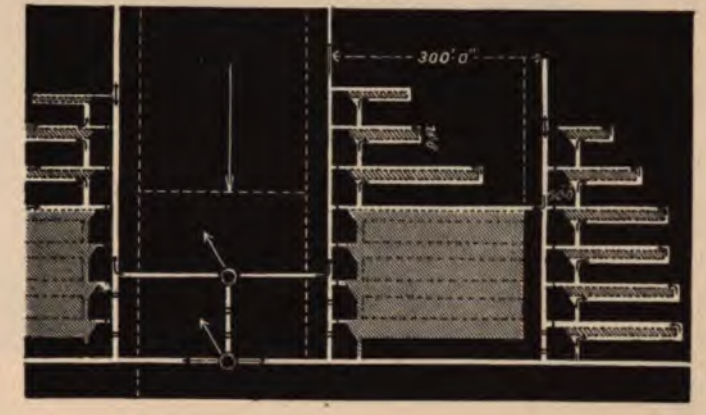
Andrew Reid, Newcastle.

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquillon upon the Working and Regulation of Fiery Mines in England.

Arrangement of the broken workings at Lundhill.
Fig. 1.



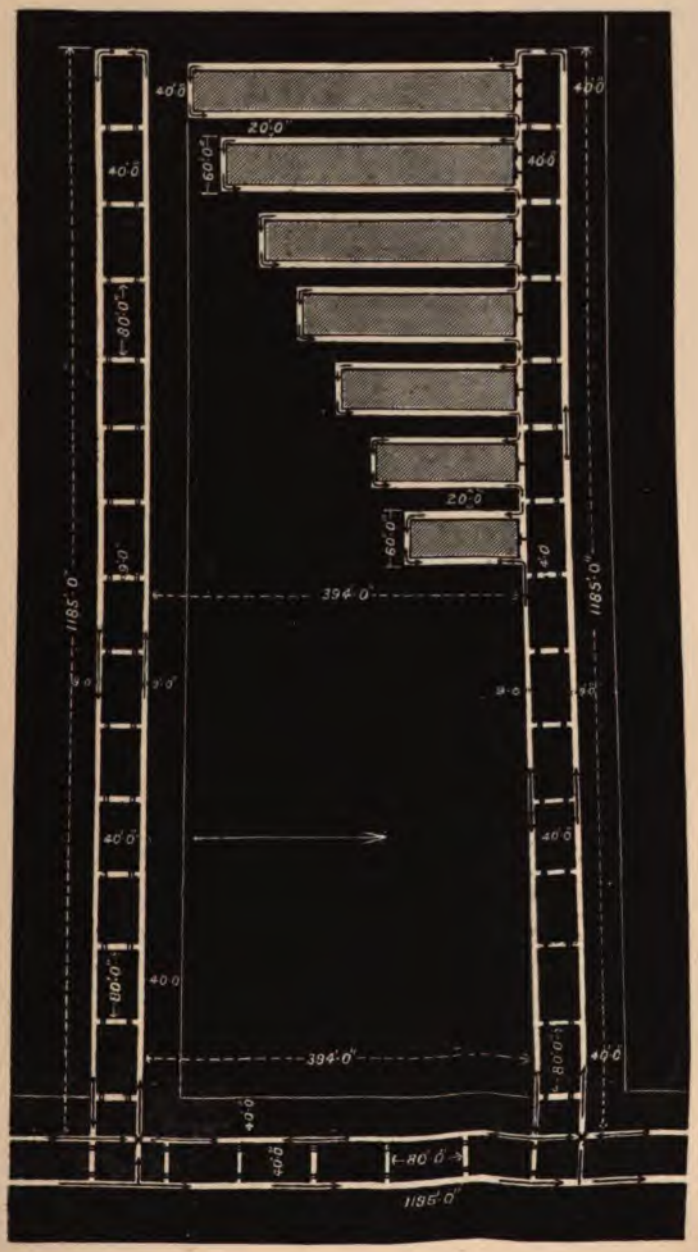
Mode of setting out the works in the pillar and single stall system, Wales.
Fig. 2.



Andrew Reid, Newcastle

To illustrate Mr A.L. Steavenson's Notes on the Report of Messrs Pernolet and Aquilon upon the Working and Regulation of Fiery Mines in England.

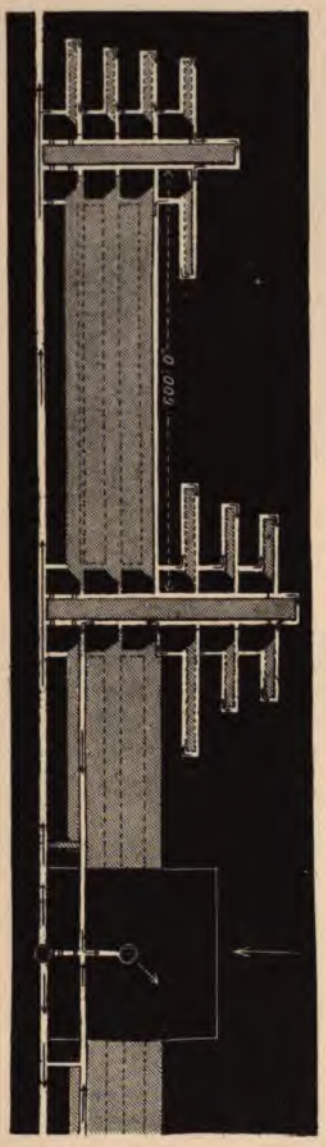
Mode of setting out the works in the Wicket System of North Wales.



Andrew Reid, Newcastle.

To illustrate Mr A.L. Steavenson's Notes on the Report of Messrs Pernolet and Aquillon upon the Working and Regulation of Fiery Mines in England.

Mode of Setting out the Works in the Pillar and Double Stall System in Wales where the Roof is very Good.

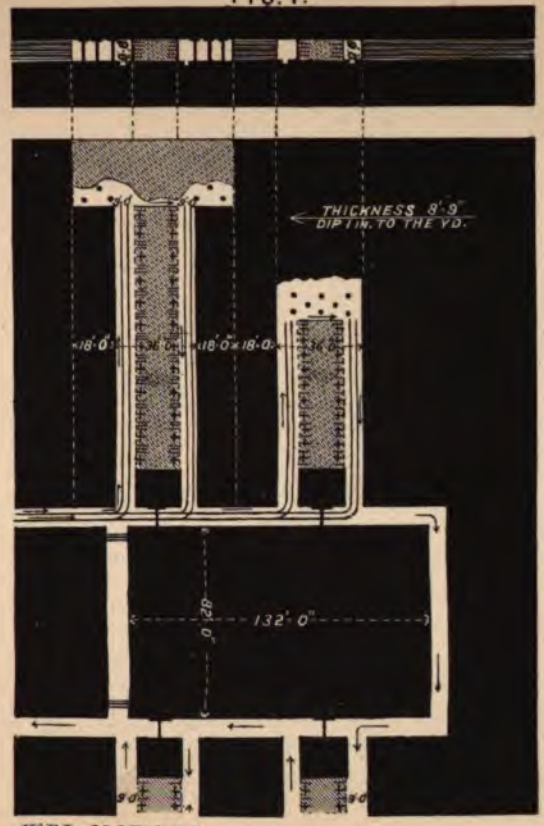


Lith. Bell & Bernasconi.

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquilon upon the Working and Regulation of Fiery Mines in England.

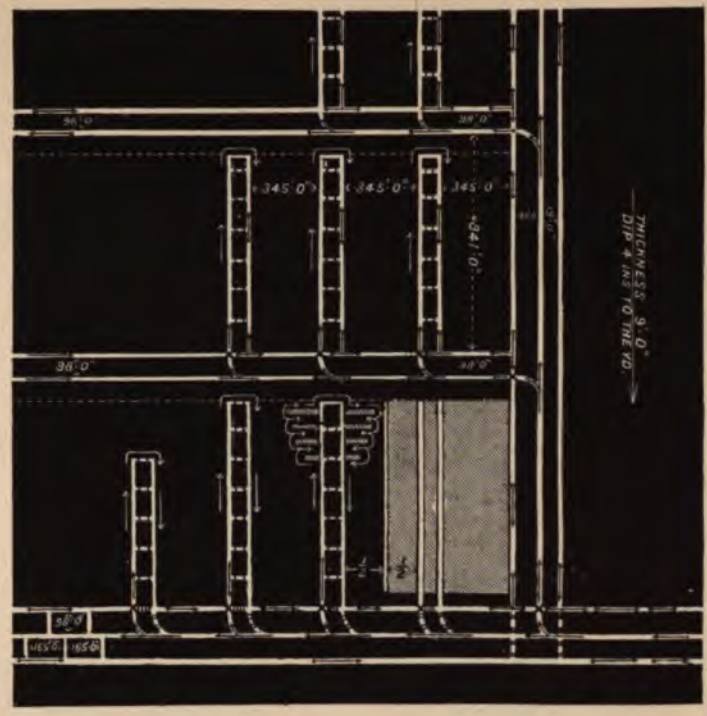
ARRANGEMENT OF THE BROKEN IN THE DOUBLE STALL WORKINGS IN THE BLACK VEIN SEAM AT CELYNEN.

FIG. 1.



ARRANGEMENT OF THE WORKINGS IN THE BLACK VEIN SEAM AT CELYNEN.

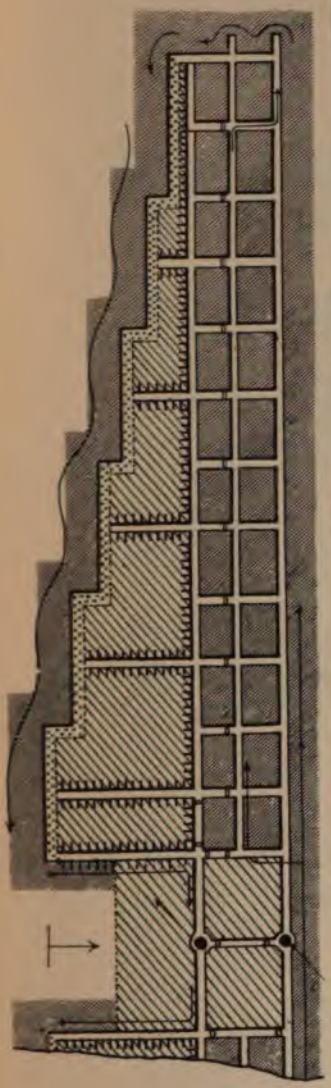
FIG. 2.



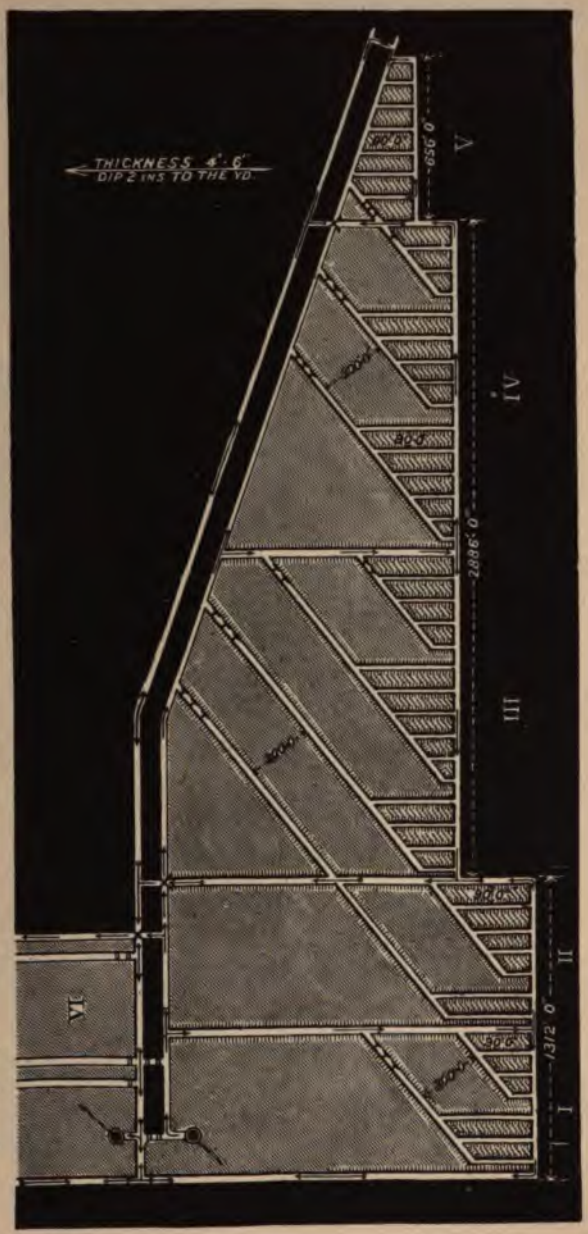
And. Reid, Newcastle

To illustrate Mr. A. L. Steavenson's Notes on the Report of Messrs. Pernolet and Aquillon upon the Working and Regulation of Fiery Mines in England.

ARRANGEMENT OF LONG WALL, WORKING OUTWARDS.
FIG. 1.



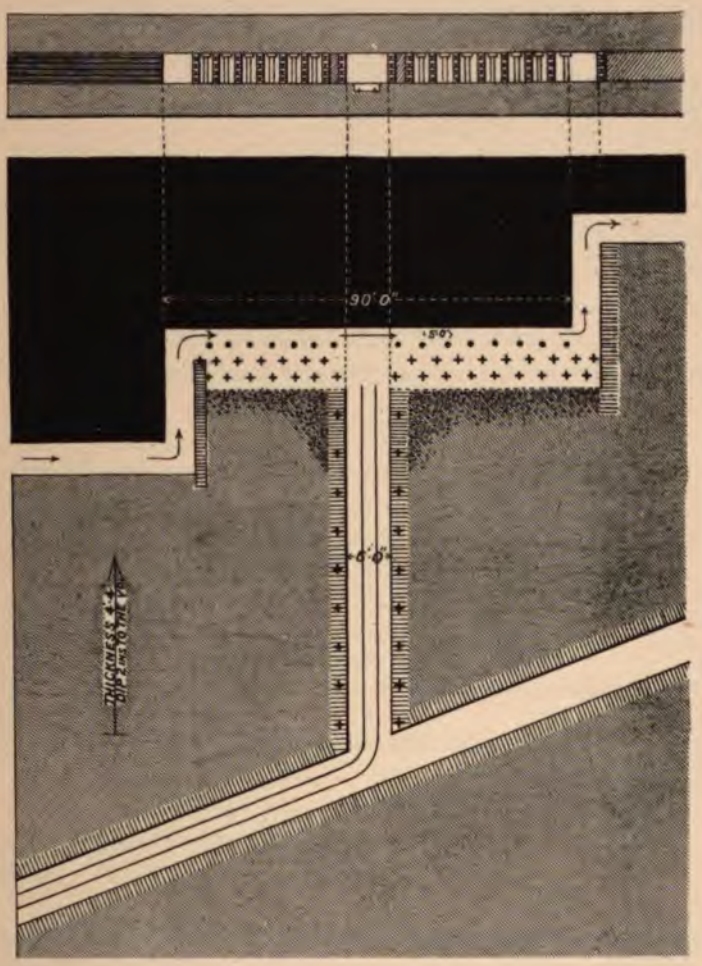
ARRANGEMENT OF LONG WALL, WORKING HOME.
FIG. 2.



Andrew Reid, Newcastle.

To illustrate Mr A.L. Steavenson's Notes on the Report of Messrs Pernolet and Aquilon upon the Working and Regulation of Fiery Mines in England.

Arrangement of the working faces in the Silkstone seam at Rockingham.



PROCEEDINGS.

GENERAL MEETING, SATURDAY, NOVEMBER 19TH, 1881, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

THE ASSISTANT-SECRETARY read the minutes of the last meeting.

The PRESIDENT said, that at a Council meeting held to-day, there had been under consideration some proposed alterations as to the days of meeting, and other matters. These alterations would be made known to the members by circular and submitted to the next meeting for approval.

The following gentlemen were then elected, having been previously nominated :—

ORDINARY MEMBER—

Mr. WILLIAM E. WALKER, M.E., Lowther Street, Whitehaven.

ASSOCIATE MEMBERS—

Mr. WILLIAM MOORE, Upleatham Mines, Marske-by-the-Sea.

Mr. GEORGE J. HENRY, Stowmarket Gun-Cotton Works, Stowmarket.

STUDENTS—

Mr. CHARLES L. WAUGH, The Burroughs, Cockermouth.

Mr. JOSH. SAMUEL SCOTT, East Hetton Colliery, Coxhoe.

Mr. HENRY B. TURNBULL, Framwellgate Colliery, near Durham.

The following was nominated for election at the next meeting :—

STUDENT—

Mr. THOMAS SOUTHERN, North Biddick Colliery, Washington Station, County Durham.

Mr. THOMAS E. CANDLER read the following "Description of a Method of Surveying with the Loose Needle among Rails and other Ferruginous Substances:"—

DESCRIPTION OF A METHOD OF SURVEYING WITH THE LOOSE NEEDLE, AMONG RAILS AND OTHER FERRUGINOUS SUBSTANCES.

By THOMAS E. CANDLER.

THE writer of this paper, in bringing it before the Institute, would ask for the co-operation of the members in forming a true conclusion as to the merits or defects of the particular mode of surveying about to be described.

It was first brought under the notice of the writer by James Henderson, Esq., C.E., Truro, who stated that it was the only method adopted by him in an underground survey of an important nature.

The writer has been unable to gather any knowledge as to whether the method of surveying with the loose needle for important surveys is at all known in the North of England; probably, if he had, this paper would not have been written, but so far as he has been able to learn, such a method is unknown; if, therefore, any member of the Institute has a practical knowledge of such method, it is trusted that he will give his experience, for the sake of the younger members of the profession.

It is, in the writer's opinion, a matter of regret that, in all the books and papers devoted to the subject of underground surveying, the magnetic needle has in all of them been decried as unsafe and useless in all surveys of any magnitude or importance; now this might have been correct if it had at the same time been stated that the inaccuracy only occurred when the bearings were read as an angle of divergence either from the north or the south points of the needle; this way of reading, however, is immaterial, and it would, in the writer's opinion, be very much better, nay, even prevent many mistakes, if the N.S.E. and West points of the compass were totally ignored in all surveys, and the bearings only read from the circle of the compass, numbering from left to right 360°.

It might be said, How then could the north line be ascertained and fixed on the plan? This indeed would be an exceedingly simple matter, as, provided a true bearing had been obtained, it would be easy to reduce any angle that had been read off from the face of the compass to a

bearing, as the West point would be numbered 90°, South 180°, and East 270°; and as the quadrants are numbered from 0° to 90° from the right and left of the north and south ends, a subtraction sum would at once give the correct bearing; this also applies to any of the bearings read, without referring to the four points of the compass, provided such bearing was not influenced by any attraction.

The methods usually adopted for underground surveying, discarding the needle, except for taking a magnetic bearing to connect the underground and surface surveys, or for the connection of two distinct surveys, are either the "rack" or the "fast needle."

In the first of these two methods it is necessary that, at some point of the survey (though it is always best at the beginning), a true bearing should be read with the needle for the purpose of a north line. The needle may be then entirely dispensed with, and, by the rack motion, the angle of divergence is read from the last sight. In many cases the vernier is put back to zero and the angle read off from the back sight; these angles have to be reduced in the book afterwards. A better process is, making the base line for the measurement of the next angle equal to the angle of the last sight. This is done by clamping the upper and lower plates of the instrument together, the plotting angle being then obtained without the trouble of reducing it.

The "fast needle" method is perhaps even better than the "rack," as by this method the instrument must be placed where there is no attraction, and a base line marked out, equal to the north and south points of the compass, from which point the survey is carried on with the rack, reading the bearings either by the four points of the compass or by the method previously recommended in this paper. One good feature in this method is that in any part of the survey the needle (if the survey is correct) should point to the north and south ends of the plate of the compass, when the sights are directed to either the back or fore drafts, and that the bearings have not to be reduced, in order to compute the survey by trigonometry.

The writer has briefly described these two methods of surveying, inasmuch as by so doing he may be able better to point out what, in his opinion, are the inherent defects in them.

In the "rack" method, unless the instrument is very perfect, there is a fear that, after the instrument has been fixed on to the back sight, (which has to be the base line for the measurement of the next angle), it may be moved slightly off when clamping the lower plate on to the legs; and again, unless the rack has a very free motion, any slight strain is sure

to cause inaccuracies; in fact it has come under the writer's observation, that so many of these screws are constantly getting out of repair, that in the end the hand has been utilized in their place by some who, being only learners, do not appreciate the error resulting from doing so.

If an error is made in any sight, even of a very slight character, this is carried on to the next sight until it becomes very serious in its nature.

The "fast needle" method has the same objection, viz.:—Any slight error is carried on to the next sight and there multiplied, and, having also to be clamped on to the legs and worked by a rack motion, it has the same objections as have been just stated.

Now, the writer considers that any method that will do away with these objections and at the same time ensure accuracy is worthy of consideration.

Perhaps it may not be out of place here to refer to what Mr. Beanlands said regarding the "Magnetic Needle," in a paper read before the Institute in the year 1871 (Vol. XX., p. 98):—

The magnetic compass, as a surveying instrument, is attended with three serious defects:—

1.—Owing to the nature of the instrument, the magnetic bearing of a line can only be observed approximately; that is, within a small fraction of a degree. The amount of this fraction cannot be precisely specified, and must be regarded partly as a matter of opinion. It depends, no doubt, on the perfection of the instrument, as well as on the care and skill of the observer. Some writers have stated this fraction at $\frac{1}{4}°$, or even as much as $\frac{1}{2}°$. This is probably an exaggeration, but the most skilful surveyors have rarely professed to read the magnetic bearing within less than $\frac{1}{8}°$ or $\frac{1}{10}°$.

2.—The needle is subject to a small daily variation of a periodical character, that is, recurring with some degree of regularity every twenty-four hours. This variation, however, occasionally takes place in a sudden and irregular manner; the changes being much more rapid, and of larger amount, than usual. Thus, variations of 10′, 15′, or even 20′ have occasionally been observed to take place within about a quarter of an hour; and alterations of 30′ within a few hours are not very unusual.

There is also a progressive variation, which is more steady and uniform in its character; the needle gradually approximating to the true meridian, at the rate of 1° in seven or eight years.

3.—The needle is liable to be much disturbed by the presence, or proximity, of iron, especially when occurring in large quantities. It is also sometimes sensibly affected by mineral substances, having some proportion of this metal in their composition.

Owing to these peculiarities, together with the large quantities of iron now generally used in coal mines, the compass is, in most cases, unfitted for use in important colliery surveys.

Now these objections are true in reference to an ordinary magnetic survey, but not one of them holds good in the method about to be described.

It seems to have become a fixed principle that the "magnetic needle" is only useful for taking the bearing or course of any line from the magnetic meridian. It will, however, be shown that with the addition of a vernier fixed and balanced on to the north end of the needle of any ordinary dial, the angular bearing of the place can be measured with as much accuracy as with an angular instrument.

Now, in conducting a survey over iron with the loose needle, it is necessary that there should be a vernier fitted on the north end of the needle, otherwise the angular bearing cannot be read with accuracy.

The survey is then commenced in the same manner as in an ordinary rack survey, using three pairs of legs.

Assume, as shown in Table I., that a *true bearing* can be taken with the needle at the first draft, this is all that is required, as the compass bearings of the back and fore sights (even though the presence of iron is all round), deducted from one another gives the angular course of the place, and this added or deducted, as the case may be, from the next *true bearing*, gives the true bearing of each future set.

It will thus be seen that the compass bearing of the fore sight of one set, and the compass bearing of the back sight of the succeeding set, being in the same survey line, should be equal, provided there was no local attraction, and that also the reduced true bearings, which are reduced from the true bearing taken in the pit, should also be equal to the fore sight of such set, and any difference shows the error that would have been made if this had been read as an ordinary magnetic bearing from the meridian.

This agreeing of the sets in cases of no attraction is exceedingly useful as a check to the survey, as when a great difference is found the cause for such difference must be looked for; thus, as shown at D, Table I., these sometimes vary considerably, and this was noted at the time of the survey and booked.

In this method of surveying, therefore, the true difference in the bearing of each set, is really read by the magnetic needle with as great a degree of correctness as with the best rack instrument.

The trouble of clamping the lower part of the instrument on to the legs, and the working of the rack itself is avoided, and there is no anxiety as to whether the compass plate reads correctly and has not moved before it has been made the base line of the next set.

The only extra work necessitated is in the booking of the sights.

Table II. shows the method applied, where it is only possible to get a *true bearing* at some point in the middle of the draft; it will be seen by referring to this Table, that the reducing of the sets to *true bearings* must commence at this point.

Table III. shows the method when a true bearing can only be got at the end of the draft.

Table IV. shows a survey made by the writer, and he submits that, with the calculations made and shown in Table V., the distance of the bearing and holing, from A to B is as accurate as could be made by the best angular instrument fitted in the most improved manner.

TABLE I.

SPECIMEN PAGE OF A DIALLING BOOK, WHERE THE NEEDLE IS USED OVER IRON, EXCEPT IN THE FIRST DRAFT.

	Compass Bearings.				True Bearings.		Links.	Remarks.
	Back Sight.		Fore Sight.					
	From L.M.		at crossing		of 3 feet		Seam.	
	°	′	°	′	°	′		
A	...		29	42	*23	21	92½	0·24 east of A, a board north.
B	29	42	46	0	39	39	101¼	
C	47	21	33	15	25	33	83¼	
D	32	17	36	0	29	16	61¾	At D a board south.
E	64	32	102	0	66	44	63	End of level. NOTE.—A large mass of iron at D and E.

* True bearing taken in Pit.

TABLE II.

WHEN NO TRUE BEARING CAN BE OBTAINED EXCEPT IN THE MIDDLE OF THE DRAFTS.

	Compass Bearings.				True Bearings.		Links.	Remarks.
	Back Sight.		Fore Sight.					
	From P.P. line		0·2 W. of		centre of		shaft.	
	°	′	°	′	°	′		
A	...		40	30	46	0	84	
B	46	0	27	03	*27	03	42	
C	27	03	34	20	34	20	320½	
D	46	0	90	55	79	15	270¼	
E	102	0	108	0	85	15	108	End.

* True bearing taken in pit.

TABLE III.

WHERE THE TRUE BEARING IS ONLY TO BE MET WITH AT END OF SURVEY.

	Compass Bearings.		True Bearings.	Links.	Remarks.
	Back Sight.	Fore Sight.			
From	former L.M.	(See July	10) in Main	Coal Seam.	
	° ′	° ′	° ′		
A	...	269 42	269 32	39½	
B	269 42	241 20	241 10	86¼	End of B at top of staple.
[C²	242 0	179 50	179 0	42	Inclination, 37° 22′. Base to be calculated.
C	179 50	284 50	284 0	38¼	
D	281 0	269 0	*272 0	46	End.

* True bearing taken in pit.

NOTE.—The difference between compass bearings in the fore sight and the reduced true bearings shows the amount of attraction.

TABLE IV.

DIALLING FROM CENTRE OF SHAFT, BOWDEN CLOSE PIT.

	Compass Bearings.		True Bearings.	Links.	Remarks.
	Back Sight.	Fore Sight.			
	° ′	° ′	° ′		
A	...	267 24	263 48	59¾	
B	267 24	250 27	246 51	48	B at cross cut, south.
[C²	246 30	206 30	206 51	104½	[C² in do.
C	206 30	251 48	252 09	85½	
D	250 45	253 33	254 57	101	
E	256 0	252 42	251 39	69¾	E at cross cut, south.
[F²	252 12	212 0	211 27	47	[F² in do.
F	212 0	253 21	252 48	89¼	
G	252 54	256 0	255 54	143½	G at crossing of north drift
[H²	253 0	322 03	324 57	44¼	[H² in do.
H	322 03	238 51	*241 45	96	End.

* True bearing taken in Pit.

NOTE.—The difference between true bearings and fore sight shows the amount of attraction. The true bearings are "cast up" from the *true bearing* taken in the pit.

TABLE V.

CALCULATION TO FIND DEPARTURE AND LATITUDE OF SURVEY.

			By Natural Sines.				
			N.	S.	E.	W.	
	° ′			Links.		Links.	
A	6 12	S. of W.	...	6 45	...	59 40	
B	23 9	do.	...	18 86	...	44 13	
C	17 51	do.	...	26 21	...	81 38	
D	15 03	do.	...	26 23	...	97 54	
E	18 21	do.	...	21 96	...	66 20	
F	17 12	do.	...	26 39	...	85 26	
G	14 06	do.	...	34 70	...	139 18	Bearing 252° 35′ or
H	28 15	do.	...	45 44	...	84 56	17° 23′ south of west.
...	...	...	...	206 24	...	657 65	

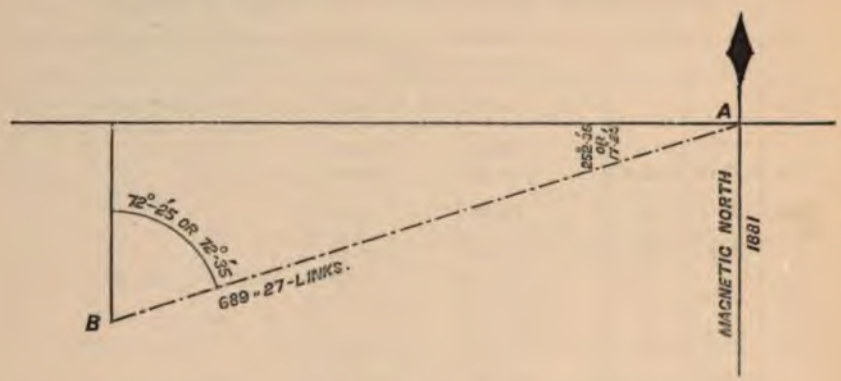
To find bearings by logarithms—

As 657·65	2·817926
: 206·24	2·314200
:: Radius...	10·000000
To tangent of ∠ opposite 206·24	9·496274 = 17° 25′ south of west.

To find distance by logarithms—

As Radius...	10·000000
: Secant of ∠ 17° 25′	10·020381
: 657·65	2·817926
To hypothesis	2·838307 = 689·27 Links.

The following woodcut shows the geometrical principle by which these measurements are obtained :—



Bearing of A to B 17°·25′, South of West or S 72°·35′ W, or in a left-hand compass 252°·35.
Do. B to A 72·35, East of North or N 72·35 E, do. 72·35.
Scale—2 chains to an inch.

The PRESIDENT said, all questions relating to underground surveys were of the utmost importance to the mining interests of the country, and any information tending to help them in any way would be well received. They must thank Mr. Candler for his paper, which would be printed in the Transactions in due course.

Mr. T. J. BEWICK's paper on "Diamond Rock Boring" was then discussed, and

Mr. WILLIAM COULSON stated, in writing, that boring being an important branch of his profession, he fully recognised the great commercial value of being able to give a correct statement of the various strata passed through, and to this end he had minutely studied all the the various modes of boring which from time to time had been invented, and he was quite convinced that for proving ironstone, limestone, or other hard minerals, no system was equal to that employed by the Diamond Rock Boring Company, notwithstanding its great cost.

Notwithstanding the accuracy to be obtained by the Diamond Borer in hard rock, and even in some kinds of coal, yet for proving coal seams in general, especially where they happen to be thin or traversed with thin bands, there was no system that he had yet seen equal to the percussion motion with rigid rods, since it then becomes of the utmost importance to have each inch of coal thoroughly proved.

Owing to unskilful men being employed, and the sides of the holes not being properly secured, a large amount of money has been expended over boring, with very unsatisfactory results; but with practical men who keep the hole properly clean, in nine cases out of ten any change in the nature of the strata can be felt the moment the chisel touches it, for there is a peculiar feel about coal known to borers, which is different to that experienced when any other kind of rock is being pierced, and as the rods are drawn at each change in the strata, and are never allowed to go more than twelve inches without being drawn and the hole cleaned, it is not possible to get far wrong in dealing with the coal.

There have been several ingenious instruments invented during the last four years for boring through coal seams, whereby in almost every case as far as 90 to 95 per cent. of the thickness of the seam is obtained.

Mr. Coulson further stated that he had proved coal in several holes, where, with the old instruments, no sample could have been got owing to large blowers of gas and water flying out; yet, with improved means, and boring only 2 to 2½ inches at a time when taking samples, he could obtain quite 90 per cent. of the seam; for although the process was slow, it was very correct, and was also the cheapest mode of proving coal seams.

In many cases these borings have been proved by sinkings to be correct to within half-an-inch.

The samples of coal obtained by this process are pieces from one-eighth to half-an-inch cube and sometimes larger.

Mr. T. J. Bewick said that, in resuming the discussion of the question of Rock Boring, he did not think he could add much, for, so far as he was concerned, the subject appeared to be exhausted. At the last meeting, when this question was under consideration, doubts were thrown upon the accuracy of Diamond Boring, and it was, in some measure, owing to this that the discussion was postponed. He was sorry that Mr. Simpson, the gentleman who more particularly criticised the Diamond Borer, was ill, and that neither he nor Mr. Coulson could be present. Immediately after the meeting referred to, he put himself in communication with Colonel Beaumont and others mentioned in his paper, to ascertain, if possible, the facts bearing upon the points which had been raised at the meeting. He found that it was rather unusual for pits to be put down on the very site of the boreholes, and, hence, he believed there were few cases on record which could prove the absolute accuracy of the hole. One particular case, however, had occurred, he thought, in the neighbourhood of Manchester, and Mr. Vivian, managing partner of the North of England Diamond Boring Company, of Whitehaven, would be able to

explain it in detail. He had received a letter from Colonel Beaumont regretting his inability to attend this meeting, but also stating that he was not aware that he could add anything to the discussion. He had hoped that Mr. Kendall, who took considerable interest in the subject on the last occasion, would have been present, but he (Mr. Kendall) had written to him stating that, owing to business engagements, he was unable to attend. Since the meeting at which this subject was discussed, the Port Clarence boring, which had been previously mentioned, had, he understood, been successfully completed. He did not know whether Mr. Wild, who had charge of this boring, was present; but at the last meeting, when the matter was discussed, Mr. Wild promised to furnish some details. He had hoped that Mr. Simpson might have enlightened them upon cases in which the Diamond Borer had not been successful; or, in other words, shewn that it had been more inaccurate than the old-fashioned boring. He (Mr. Bewick) could not but say that, as a supporter of the Diamond Rock Borer, he felt gratified at the remarks made by Mr. Coulson, who candidly informed them that, except for coal, no other system was equal to that of the Diamond. With reference to coal he was prepared to question the point with Mr. Coulson. He (Mr. Bewick) thought it must be clear to any one that the system of getting up cores, or getting through the softest coal, could not possibly be better done than by the Diamond Borer; and this view he believed Mr. Vivian would corroborate. In his notes Mr. Coulson stated that he bored only from 2 to 2½ inches at a time to take a sample, and the process, although slow, was very accurate. Gentlemen acquainted with deep boring know that to bore only 2 or 2½ inches, and then have to draw the rods each time, must indeed be slow; and he could scarcely conceive how they would do with that system in borings reaching 2,000 to 3,000 or 4,000 feet, as had been done by the Diamond Borer. Mr. T. W. Benson on the last occasion favoured them with some remarks, and he believed that gentleman was now prepared to show them the cores actually obtained from a hole in the Hexham district. Within the last few days he had met a gentleman from London who lately spent some time on the banks of Lake Superior, and who told him that the Diamond Borer was being very extensively used there in explorations which were being made for copper. He (Mr. Bewick) never thought that the Diamond or any other system of borer was adapted for metalliferous mining; but the gentleman assured him that it was done. The veins in the Lake Superior district are not vertical, but at an angle perhaps of from 45 to 60 degrees from the horizon; and the boring is done at an inclination approximating that of a right angle to the vein.

Mr. JOHN VIVIAN said, he had been very pleased to hear Mr. Coulson's notes, and it would have given him greater pleasure if Mr. Coulson had entered more fully into the subject. What mining engineers were desirous of getting was the best, quickest, and cheapest system of boring; but, whilst desiring to do the work cheaply, of course the greatest point was accuracy. Many people spoke of the Diamond Borer without knowledge of it; and, on proper information being given, those who had been opponents had been converted into the very strongest supporters. He did not want by such remarks to prejudice them in his favour; he could substantiate what he stated by letters which he held in his hands. Unfortunately in the early days of Diamond boring there was such a great pressure and demand for the appliance that it was frequently sent out with unskilled and inexperienced men, and no doubt accidents happened and difficulties arose; but of late years—and he could speak personally of this—all the work they had done had been so satisfactory that he thought their clients returned to them very frequently. He could mention several cases, and he had no doubt that the President could state his opinion of the Diamond boring system, which had come under his notice. Mr. Coulson stated that the Diamond boring system was very good, and that nothing could be better for hard rock. He was glad to hear this from such a high authority as Mr. Coulson; but he rather differed from that gentleman when he spoke of coal as being beyond the capability of the Diamond Borer; because with it coal had been proved at very great depths. He had bored coal near Manchester to a depth of 1,050 yards, and since that the pit had been sunk to a depth of 950 yards, and coal was being won there.

He had received the following letter from the Engineer :—

Ashton Moss Colliery Co., Audenshaw, near Manchester,
1st April, 1881.

DEAR SIR,—With reference to your enquiry as to the accuracy of your borings, as proved by actual sinking, I am happy to say the difference in measurement has been very slight. The principal seam of coal was given by your men, thus :—Coal, 6′ 4″; shale, 1′ 2′; coal, 10″; shale, 1′ 5″; coal, 7″. By sinking we proved the thick bed to contain two small bands of dirt—one ½″, and the other 2″ thick, but with that exception, all was correct. Believe me, yours faithfully,

JOHN GREENWOOD, Jun.

From that thick seam of coal there were brought up solid cores 5 inches diameter, and 6 or 7 inches long, and some of them longer; and some small lumps and dust were also brought up. These cores were taken by the engineer, put into a tube, and tested for coking purposes immediately after coming up from the borehole. As the specimens obtained from the boring were valuable to the persons for whom the boring was

effected, he could not get many of them, but he had two which he would be happy to show the meeting; they came from a depth of from 600 to 900 feet, but he would not mention the name of the place they came from. In boring soft measures they frequently bored in a hole where there was a very serious run; that is, a soft bed of shale with water in it, and they had continued their boring from 150 to 200 feet below that run. The hole at Audenshaw was commenced with a diameter of 9 inches, and was finished with a diameter of 4½ inches, 1,050 yards down. He thought if Mr. Coulson had seen the Diamond boring system he would have been able to understand that, with it, they could bore in softer measures better than he imagined. As to coal seams, they obtained with the Diamond Borer 50 to 70 per cent. of core, and in addition to that they had got small lumps and dust. He had several letters which any member who desired could read. He had received the following, dated May 4th, 1881, from Platt Brothers and Co., Limited, Hartford Works, Oldham :—

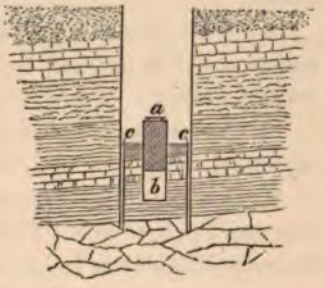
> We duly received your note of the 30th ultimo, and beg to confirm our telegram of this morning, wherein we advised you that the boring has struck the Big mine coal, and that we are so satisfied upon the point, it is unnecessary to continue the hole any further. The cores brought out have been so satisfactory, and correspond so fully with the strata in our pit shaft on the other side of the large fault, that for some weeks we have known exactly the position of the seams, and were somewhat inclined to discontinue the prospecting sooner.

In his notes Mr. Coulson spoke of the peculiar feel when coal was touched. Of course there was a peculiar feel, and this, to some members who did not understand boring operations, might seem rather ridiculous to speak of; but it was so. If a man had hold of the brace-head he felt the coal immediately, unless the hole was dirty, and there was shale or clay in the hole. In the Diamond boring system the man watching the machine could tell immediately it got to the top of the coal; there was a peculiar action of the machine by which a trained man could both feel and see that it had got to coal. It required a trained man, and this would explain how, in the early operations of the Diamond Boring Company, some little accidents may have happened. Some people may have gone into a district which they thought was a coal-field, and because, on boring, they did not find coal, they may have blamed the system. He did not say that was the case. If the persons proved afterwards, by sinking, that there was coal, then he must confess it was the fault of the system; but still, unless there had been a sinking, it was open to doubt that coal existed there. Of course coal was broken off sometimes by faults, or it might thin out occasionally. Mr. Bewick had spoken of explorations with the Diamond Borer in Canada by boring at an angle. The same thing had been adopted in Australia in ex-

ploring for gold; they bored vertically, and then at an angle, right and left, with the machine in the same position but angled, and by that means felt where the vein was. He would be happy to answer any questions.

Professor LEBOUR said, he would like to ask Mr. Vivian a question, which would be of more interest to the pure geologist than to those who looked upon geology as a means and not as an end. In the neighbourhood of London lately there had been borings by the Diamond system, and cores had been brought up from the palæozoic rocks beneath the Secondary and Tertiary beds of the Thames basin, and certain theories based upon the dip shown by such cores. He wished to ask Mr. Vivian whether he thought that the evidence of the dip brought in a core from a great depth was good evidence, and whether the cores were brought up with so little motion that the direction of the dip could be told, and, if so, how. Mr. Bewick mentioned a point which was of considerable interest geologically, and that was that sinkings were very seldom carried out exactly in the same place as where the borings were made. He had no doubt a great number of the discrepancies they read about were due to that, and to the non-consideration of one of the commonest facts, that, especially in Coal Measures, there was a constant thickening and thinning of the intermediate beds between the coal seams. Although the coal seams were, on the whole, constant, some of the beds between them were very inconstant; and it was often owing to this, he thought, that there were such great discrepancies between borings and sinkings.

Mr. VIVIAN said, there was a difficulty in fixing a dip of any seam passed through by the Diamond boring method except in one way, which was to bore three holes. Of course every adventurer when seeking minerals wished to have it done in the cheapest way; thus, generally, in boring they were not allowed to put down two or three holes. He had, however, a method of his own, which was shown in the annexed woodcut. This was simply to bore a small hole (*b*) in the centre of the hole, and then to adjust a compass (*a*) in a wooden plug, and lower it down till it was fixed firmly in *b*; a groove (*c*) was then bored round it and the core brought out with the compass attached.



A discussion then arose as to the difficulty of fixing the needle when the compass was attached to the strata *in situ*, which it is unnecessary to record, as a description of a mode of placing the compass in a bore rod with clock-work attached so as to fasten the needle after any given lapse of time will be found in Vol. XXIX., page 64, of the Transactions. The compass with the clock-work could, therefore, be lowered down and attached to the hole by means of a plug, as Mr. Vivian had proposed, and at the end of twenty minutes or so, when the needle had got quite steady, the clock-work would fix it, and the core could be brought up with the actual bearing it had before it was separated from the earth.

Mr. T. W. Benson said, he did not know that he had anything to add to what he stated a few months ago. He had brought with him the samples that were supplied by the Diamond Rock Boring Company just as they came out of the hole. So far as regarded boring through small bands in a coal seam, he thought that the cores he now showed would bear out what the Diamond Boring Company stated—that the Diamond borer was better than the old system. The cores of band brought up were about one inch thick, and were brought up in a perfectly good condition. Since the time the hole was put down, seven years ago, the size of boreholes had been much increased. In boring through a coal seam a better result was obtained with a hole of 5-inch diameter than with one of 1½ inch diameter. The perfect accuracy of the boring of the hole had not been proved by an actual sinking; unfortunately, or rather fortunately, the result was not of such a nature as to tempt the explorers. Had they got a good result at that time it might have induced them to spend a large sum of money, which would have been unproductive in the bad times which have since existed.

Mr. D. P. Morison asked Mr. Vivian whether the Diamond boring system could be applied to horizontal boring in drifts as well as in vertical sinking?

Mr. Vivian said it had been applied to drifting, but it was found expensive.

The President said, the discussion had been an interesting one. They were much obliged to Mr. Vivian for attending the meeting and explaining the subject so ably as he had done. It appeared, after all, that there was a necessary training, both for hand boring and for a person managing the Diamond Borer: one depended upon the touch or feel with the hand on the brace-head, and the other on the eye which looked at the different motions of the machine. It was a question whether a man was more likely to forget what he had to look at with the eye, or what he touched with his hand.

He had had experience of Diamond and hand boring. A very experienced borer, by the touch of the hand, which when once acquired was something exceedingly delicate, could bore so that the results might be thoroughly depended upon; and he did not think an experienced borer would pass a half or even a quarter of an inch of band. With respect to the discrepancies which had been mentioned, he almost went further than Professor Lebour, because he had found that many of the smaller seams were not constant, and he (the President) did not think any one could fairly say that the strata passed through by a borehole had not been correctly stated unless a sinking had been made on the identical spot where the boring had been made.

The discussion upon Mr. J. D. Kendall's paper on "The Iron Ores of Antrim" was adjourned, as Mr. Kendall was not present.

Mr. Bewick said, that at the February meeting, when Mr. Kendall's paper was read, he (Mr. Bewick) was in the chair, and neglected to submit a vote of thanks to Mr. Kendall. He now wished to rectify the omission, and proposed that Mr. Kendall be thanked for his paper.

Professor Lebour seconded the vote of thanks, which was unanimously agreed to.

Mr. Bewick then exhibited a specimen of hematite iron ore which had been kindly sent by Mr. Kendall, on which was a well-defined fossil bivalve, believed to be the only one of the kind yet met with in the Whitehaven district.

Professor Lebour said, that the specimen was especially interesting, as being perhaps the best evidence in favour of Mr. Kendall's replacement theory that could be brought forward. It was evidently a piece of limestone, semi—or more than semi—converted into hematite. How that took place he did not know; he did not think it had been explained yet.

The meeting then concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 17TH, 1881, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. B. FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The SECRETARY stated that Mr. May had presented to the Institute a very old book, by John Curr, of Sheffield, called "The Coal Viewer and Engine Builder's Practical Companion."

On the motion of Mr. Simpson, seconded by Mr. Bewick, a vote of thanks was passed to Mr. May for the book.

The PRESIDENT said, that a series of resolutions adopted by the Council, with regard to future meetings of the Institute, were read at the last meeting, and he then promised that the resolutions would be printed and circulated. He believed a copy had been sent to every member, and he would be glad to hear observations upon them. Members would see from the circular calling the meeting the nature of the changes the Council had proposed to make in the number of meetings and other matters. They were as follows :—

That the present number of General Meetings each year be reduced from ten to six, to be held at intervals of about two months.

That each year there shall be one meeting held in some place other than Newcastle, such place to be fixed by the Council.

That the Council shall meet every month in addition to their meeting on the days of the General Meetings.

That the present day of the week and hour of meeting remain unaltered.

That there shall be a dinner every year, not to exceed 7s. 6d. each, without wine.

That these alterations be tried for twelve months as an experiment.

He need not add that these changes had been proposed, with a view of adding to the interest of the meetings and forwarding the interests of the Institute, and he invited the fullest possible discussion on the subject.

The resolutions were passed *nemine contradicente*, after which the following gentleman was elected, having been previously nominated :—

STUDENT—

Mr. THOMAS SOUTHERN, North Biddick Colliery, Washington Station, Co. Durham.

Mr. CHARLES PARKIN read the following paper on "Jet Mining :"—

ON JET MINING.

BY CHARLES PARKIN.

It may appear at first that such a purely ornamental material as jet is hardly a suitable subject to bring before the notice of the members of this Institute, but the fact that it is sought for and wrought at considerable personal risk to the miner, and that the mining for it is subject to the Coal Mines Regulation Act, suggests the idea that a few remarks on the question may not be, after all, inappropriate; and although this mineral has been worked for many years, yet so little is known of the method of obtaining it—except to those closely interested in the trade—that the writer hopes a brief description of its geological position and the mode of working it will not be out of place in the Transactions of the Institute.

GEOLOGICAL DESCRIPTION.

In Dr. Page's Handbook of Geological Terms it is stated that the word "jet" is derived from Jayet, or Gagites, terms in their turn derived from Gaga, the name of a river in Asia Minor, and that he considers jet to be more of the nature of amber than of coal, stating that in Prussia it is known as "black amber."

Young and Bird in their survey relate that in front of the cliff north of Haiburn Wyke, near Whitby, was found the petrified stump of a tree in an erect position, three feet high, and fifteen inches across, having the root—consisting of coaly jet—in a bed of shale, whilst the trunk in the sandstone was partly of petrified and partly of decayed sooty wood.

Phillips, in his Geology of Yorkshire, states that "jet is simply a coniferous wood, and in thin sections clearly shows the characteristic structure, frequently resinous masses of oval figure enveloping larger tissue than occurs elsewhere appear under the microscope," and also "that impressions of ammonites and other fossils appear on surfaces of jet, proving that it has passed through a condition of softness."

The best jet is usually found in the largest quantities towards the base of the upper lias or alum shale stratum, and this portion is generally known as the jet rock; a softer jet is obtained also throughout the shales above, in

the oolite series, but in less quantity. The jet rock is about 18 feet thick, lying a few fathoms above the Cleveland main bed of ironstone, but below the top seam, which is worked in the Rosedale Abbey and Grosmont district known as the oolite ironstone. The shale is bituminous, and a thin piece when lighted will burn by itself; on being exposed to the atmosphere it sometimes takes fire, when it assumes a reddish hue, due no doubt to the iron which it contains; water flowing through this shale leaves it impregnated with alum, and destroys vegetation. An instance of this may be seen at the Slapewath old Alum Works, near Guisbro'. The jet deposits vary in size, and although when found are termed seams by the miners, yet this term is not a correct one, the jet lying irregularly through the whole depth of the shale, ranging from a wafer to 5 or 6 inches in thickness; and in length up to several feet, the breadth of the deposit being only a few inches.

Mr. Matthew Snowdon, of Whitby, in a letter to the writer, remarks: —"We have often got large quantities of jet down here in working the oolite ironstone seam, and in one instance, at Port Mulgrave, we found a deposit for which I had £700 offered. We came across it between the oolite ironstone seam and the freestone." The shape of the deposit was like that shown in the woodcut.

MODE OF WORKING.

The number of men actually employed in jet mining would be somewhat difficult to arrive at, for no accurate record is kept (to the writer's knowledge) either of the men employed or the quantity of material worked per annum. Slight accidents have been of frequent occurrence; and in 1873, a jet miner was reported to have been killed by a fall of shale, owing no doubt to the careless way in which the operations were carried on.

The search is always commenced at the outcrop of the alum shale, two or four men forming a company. Shafts are not sunk, either to win or to work it. A drift 6 feet high by 3 or 4 feet wide is driven in from the outcrop, when these drifts are advanced a few yards; side excavations are made, and the systematic search for jet commenced. The shale over the roof of the side drifts is hewn or wedged down, serving as a platform to work on, and the whole thickness of the shale is then explored in a fashion somewhat resembling a combination of longwall in coal work, and of stopeing in lead and other metalliferous mines. While the preparatory drifts are being driven, the shale has to be conveyed outside, but in the

regular course of working most of it is tossed back, and as little taken out of the mines as possible, horses or lads hardly ever being required. When a discovery is made, the deposit is carefully followed up and excavated in as large pieces as possible; sometimes weeks will elapse and no jet be found, while occasionally exceptional luck is met with, and a great quantity got in a few days. On such occasions the so-called seam is very seldom left until all is extracted, and the miners work night and day. The reason for this caution is obvious, for should it become known that a good deposit has been met with, if the mine was left, the jet might be stolen and carried away during the night.

The workings seldom extend beyond a hundred yards at the most from the drift mouth, the shale becoming much more difficult to work as operations are extended from the outcrop.

MEANS OF VENTILATION.

If when a drift is driven in for some distance the prospect is found to be cheering, another drift is commenced running parallel with, and at a distance of about five yards from the main one, and the two connected in order to secure ventilation, but the plan more generally adopted at the present time is that of allowing the roof to fall away to the surface when explorations are being made near the top of the jet rock.

An explosion of gas is reported to have taken place some years ago in a jet mine, which was probably due to the oily vapours exuding from the shale; and in the ironstone mines of the district explosions have occurred probably from the same cause. The writer would here acknowledge his indebtedness to a letter which appeared in the *Mining Journal* for this fact and some other particulars contained in this paper.

TIMBERING AND BLASTING.

Very little timber is required in these drifts, as the jet-bearing rock is of a very tough character, and no gunpowder or other explosive is necessary in working the shale, the nature of it being opposed to successful blasting, which would moreover injure any jet lying near.

ROYALTY CHARGES, YEARLY PRODUCTION, AND COMMERCIAL VALUE.

Owing to the uncertain character of the speculation it is a very difficult matter to fix upon an equitable and reasonable royalty charge, and in most leases or agreements granted for the working of ironstone and other minerals, when jet is included, the terms for working it are embodied in

the unsatisfactory words of "a rent to be agreed upon, or, failing agreement, to be determined by arbitration." But it is customary to arrange the matter by a payment varying from 2s. 6d. up to 3s. 6d. per week for each miner employed.

The quantity of English jet used per annum at present only amounts to three or four tons, its value varying from £300 to £1,300 per ton, whilst the quantity imported from France and Spain is over 100 tons per year, the foreign supply being so much cheaper, that from France costing the manufacturers only about £30 per ton, and the Spanish from £60 to £140 per ton. The English jet, however, is superior to that obtained from abroad, which is much more liable to fall to pieces on sudden exposure to the sun or other sources of heat.

LOCALITY OF MINES.

The Yorkshire jet mines are situated in the North Riding, and are to be found principally within a few miles of Stokesley, at Swainby, Bilsdale, Rosedale Abbey, and neighbouring district. Jet is also wrought from the sea cliffs, in open quarries in the neighbourhood of Whitby, the supplies from Kettleness having been very large. The Eston range of hills has also yielded a good deal of jet in years past. Operations are at the present time going on at Swainby and Bilsdale, where Mr. Hall, of Whitby, is working; and on the west side of Rosedale, on Gillbank Farm, where the results are turning out very encouraging; and it is anticipated that other parts of the dale will be explored, the jet from Gillbank having proved to be of superior quality.

MANUFACTURE.

That jet manufacture is of ancient date is evident from the fact of it being on record that from the Sands-End cliffs it was procured and used in making ornaments by the Romans at their station of "Dinum Sinus" (Dunsley Bay). The writer has himself seen a fourteenth century jet ornament.

"Whitby Jet" is a term which seems now to be accepted as a guarantee of the good and genuine quality of the articles manufactured out of this mineral, and the town is justly famed for this branch of industry, for considerable ability and ingenuity is shown in the bracelets, necklaces, ear-rings, brooches, watch-chains, and other fancy articles made. Upwards of 400 men and boys are employed in the Whitby manufacturing trade, who work nine hours per day. The men are paid about 25s. per week, and the lads from 6s. to 10s. per week.

Mr. Thomas Boyan, one of the principal manufacturers in Whitby, has

been kind enough to allow an inspection of his works, which enables the writer to briefly describe the process through which this mineral has to go.

The first process in the manufacture is stripping the skin off the jet (this skin is of a blue colour in that obtained from the alum rock in the cliffs near Whitby, and of a brown colour in that obtained from the jet rock proper in the mines further inland); this operation is done by workmen chipping off the outside with a short chisel; the substance is then passed on to be sawn into various thicknesses and sizes. In this process the greatest economy is observed, and the apparently useless fragments are made up into beads and small ornaments according to their size and shape. The cut pieces are then put into the hands of workers, who with foot-treadle grindstones take off all the sharp edges and bring them into oval, circular, or other geometrical shapes required. In the next stage it passes into the hands of the carvers and turners, the former with knives, chisels, and gouges, bringing the pieces into beautiful designs, with a degree of accuracy and rapidity that could hardly be credited. From the carving department the work is transferred to the polishers, who first treat the rough work on polishing boards having a surface of rotten stone and oil, and after this treatment comes the finishing polish, or, as it is termed, "rougeing," which is accomplished by holding the article against a quickly revolving wheel covered with walrus hide for the broad surfaces, and strips of list fixed on end for the indented or carved portions, or against a revolving brush wheel, all of which are covered with rouge. This rouge consists of a red oxide of iron powder and water. It then only remains to fix the article into its setting to become ready for sale.

Ammonites (molusca shells), commonly known as snake stones, are richly polished and inserted into many of the ornamental articles, and these are obtained in great abundance in the alum shale, and on the sea-shore scar at Whitby.

There are reasons to believe that the trade will receive a great impetus from the introduction of jet into the enamelling art. Mr. Charles Armfield, Diocesan Surveyor, York, writes to the *Builder* to call attention to a new means of decoration. It is the invention of Mr. Godfrey Hirst, of Whitby, and consists of a combination of enamel with jet. Mr. Armfield states that, from specimens of the work he has seen, he believes it will form a very valuable artistic addition to the legitimate means of decorating furniture, pulpits, reredoses, etc. It is well known that jet is capable of a very high and endurable polish, and he (Mr. Armfield) has seen a thirteenth-century jet cross, found buried on the site of Grosmont Priory, near Whitby, which is still in a perfect state of polish. It may not be

generally known that it possesses, in a unique degree, the power of absorbing the radiations of adjacent colours, so that when used with any other colour than yellow, it produces a wonderfully soft effect, and gives a richness of tone which no other black material is capable of producing. That gentleman further states that he has used jet instead of crystals or sham pearls for jewelling embroidered altar frontals, and was astonished on his first essay with the materials to find that the jet bosses, worked on a deep crimson ground, at ten yards distance, looked like carbuncles. At first he thought it was the result of reflection upon the rounded surface of the boss, but a little more thought soon made it apparent that this was not the case, and an experiment with a flat disc of jet, on a similar ground, gave a clue to the real cause. This valuable quality of radiation absorption showed itself very strong on the blue, but less on the red, grounds.

In connection with this subject, it seems worthy of consideration that, if the shale excavated from the mines could be utilized—and, it must be remembered that it contains both alum and oil—this, in conjunction with the working of jet, might make it a subject more worthy the attention of capitalists.

Phillips says: "The petroleum generally sought for is usually found in most quantity above the jet rock. It is found in the joints of the rocks, in the cells of ammonites, and in other situations which seems on the whole suggestive of a process of distillation from carboniferous compounds in the shales above;" and in many of the Cleveland mines the smell of it is very perceptible.

It is asserted that Sir Thomas Chaloner established the first Alum Works in England, at Bellman Bank, near Guisbro', in the year 1600; these were vigorously worked until the year 1792, and in 1852, they were re-opened after having laid idle for sixty years. The Guisbro' works proving so successful, other speculators were induced to embark in these undertakings, and about the year 1615, works were opened at Lofthouse, Boulby, Kettleness, Sandsend, and Saltwick, near Whitby, all of which were supplied from the Sea-cliff quarries of alum rock, within ten miles north, to about seven miles south of Whitby. The Lofthouse and Boulby Works, were the most extensive in the kingdom, and the New Boulby Works belonging to a Mr. Baker, in the year 1858, employed about 100 hands. The alum trade, doubtless, laid the foundation of the future importance of Whitby. The number of inhabitants of the town in 1610, was 1500, whilst in 1650, the number had increased to 2500, due entirely, it is said, to the introduction of the alum trade to the district. The

shipments from all the works were made here, and exported to France, Holland, and other Continental places, but after some time the demand from abroad began to fall off, until the trade gradually became confined to the home market, supplied through the ports of London and Hull, and of late years nothing has been done at these works, most of which have been permanently closed for some time past.

It is very evident, however, that a large business has been carried on for more than two centuries, which points to the conclusion that the speculation proved to be a remunerative one, and the writer is led to consider it a question worthy of investigation, as to how far it would be practicable to combine jet mining, with the working and manufacture of alum or shale oil. With regard to the resources of alum shale now available, they may be considered as practically inexhaustible.

The PRESIDENT said, Mr. Parkin need not have apologized for his paper, which all would consider a very interesting one, whether looked at in regard to jet itself, or in regard to alum works. He was afraid alum works were among the dead industries of the country. He had been connected with them, but the market for alum was gone, and that substance was superseded by other chemical substances.

Professor LEBOUR exhibited a few specimens, which he thought might illustrate some of Mr. Parkin's remarks. There were, he said, specimens of Whitby jet, and among the others were the chief varieties of asphalt and mineral bitumen found elsewhere; and they would see that there was some connexion between all of the specimens. As to the word "jet," Mr. Parkin quoted a derivation from the river Jayet. The same derivation was given for agate. Those substances were not the same things, and yet the same derivation was given for each. One must be wrong. Jet was found in the upper and middle lias of England, also in the Kimmeridgian beds on both sides of the Pyrenees, but chiefly on the south or Spanish side. It was of the same character as the English jet, but was not of such good value for commercial purposes. The optical character of jet mentioned by Mr. Parkin was quite new to him; that, he thought, was the most important part of the paper; and, in addition to being a subject of interest to capitalists, it was also a subject of interest to physicists. Mr. Parkin had quoted Professor Phillips' description of jet as showing in microscopical sections distinct signs of tissue, so that he looked upon jet as simply altered wood. He (Professor Lebour) had no doubt that Professor Phillips was right as to the sections which he happened to observe, but Professor Phillips' day was not the

day of microscopic sections. He (Professor Lebour) had no hesitation in saying that in many sections of jet no tissues of that kind would be observed.

Mr. PARKIN said, he had seen on the surface of jet the impression of something like a fern, but he had not the specimen to show to the members.

Professor LEBOUR—That was extremely likely. Anything like jet or asphalt, when in a soft condition, would be just the matter to retain the impression of vegetable matter in perfection.

Mr. BOYD said, it might be reasonable to conclude that the impressions of fossils on jet would be the remains from inland waters, and not from sea deposits.

Professor LEBOUR—Yes, unless they are drifted.

The PRESIDENT moved a vote of thanks to Mr. Parkin, which was seconded by Professor Lebour, and unanimously carried, and the discussion was adjourned.

Professor LEBOUR, M.A., F.G.S., read the following paper on "The Present State of our Knowledge of Underground Temperature, with special reference to the Nature of the Experiments still required in order to improve that Knowledge:"—

ON THE PRESENT STATE OF OUR KNOWLEDGE OF UNDERGROUND TEMPERATURE, WITH SPECIAL REFERENCE TO THE NATURE OF THE EXPERIMENTS STILL REQUIRED IN ORDER TO IMPROVE THAT KNOWLEDGE.

By G. A. LEBOUR, M.A., F.G.S.,

Professor of Geology in the University of Durham College of Physical Science, Newcastle-on-Tyne.

The principal object of the writer in presenting this paper to the Institute is to enlist the co-operation of mining engineers in carrying out some of the experimental researches which appear to be still wanted in order to place on a firmer basis our knowledge of the rate at which the temperature of the earth increases in going downwards. Without such co-operation the present state of knowledge on the subject could never have been attained, confessedly imperfect though it be, and without more aid of the same kind it is not likely to be much increased.

The writer will first give a brief and condensed account of the experimental results already arrived at; he will then enumerate the chief sources of error which must be taken into account in estimating the relative value of such results; and he will conclude by suggesting a few lines of inquiry and observation, in which the help of practical engineers would be of the utmost value.

In the following tabular statement will be found a list of some sixty sets of observations of underground temperature arranged according to the average rate of increase of temperature in depth :—

TABLE I.

Place.	Depth from Surface (in feet) of Deepest Observation.	Increase of 1° F. per Foot.
1. Anzin, in the north of France, Shaft 3 ...	473	28·1
2. Do. do. do. Shaft 4 ..	443	28·4
3. Weardale, Slitt Hill Shaft	660	33·5
4. Cornish Mines, mean	552	34·8
5. Anzin, Shaft 2	607	37·7
6. Allenheads, High Underground Engine Shaft	807	40
7. Cornwall and Devon, mean of 415 observations	672	40·8
8. South Balgray, west of Glasgow	525	41
9. St. Petersburg	656	44·1
10. Oolitic Coal Mines of Virginia, U.S. ...	600	45
11. Anzin, Shaft 1	656	47·2
12. Boldon Colliery, Durham	1,514	49
13. Blythswood, near Glasgow, Bore 1 ...	347	50
14. Mouillelonge Mine (Saône-et-Loire) ...	2,676	51
15. Sperenberg, near Berlin	3,390	51·5
16. Sich's Brewery, Chiswick, near London ...	395	52 (?)
17. Yakutsk, Siberia	540	52
18. Kentish Town, London	1,100	52·4
19. Do. do.	1,100	52·9
20. Blythswood, Bore 2	354	53·5
21. Kentish Town, London	1,100	54
22. Rosebridge Colliery, near Wigan ...	2,445	54·3
23. Oolitic Coal Mines of Virginia, U.S. ...	780	54·6
24. Neue Salzwerk, Westphalia	2,281	54·68
25. Near Geneva	(?)	55
26. Torcy Mine (Saône-et-Loire)	1,951	55·2
27. Military School, Paris	568	56·25
28. St. André's Well, 50 miles west of Paris	830	56·4
29. Grenelle, Paris	1,794·6	56·9
30. Mendorff, Luxemburg	2,394	57
31. South Hetton Colliery, Durham	1,936	57·5
32. Monkwearmouth Colliery, Durham ...	1,499	60
33. Channel Islands (Sark and Herm) ...	222	60
34. Swinderby, west of Lincoln	1,500	62·5
35. Fowler's Colliery, Pontypridd, S. Wales	846	62·7
36. Allenheads, Gin Hill Shaft	440	66·6
37. Kingswood Colliery, near Bristol... ...	1,769	68
38. Manegaon, India	310	68
39. Saint Louis, North America	3,837	68·5
40. Swinderby, west of Lincoln	2,000	69
41. La Chapelle, St. Denis, near Paris ...	2,065	72·8
42. Crawriggs, Kirkintilloch, near Glasgow...	350	75
43 to 47. Schemnitz, in Hungary, 5 places ...	1,358	75·5
48. Astley Pit, Dukinfield	2,055	80
49. Irish Mines (Wicklow, Waterford, Cork, and Kerry), mean	342	84·6
50. Seraing, near Liége, Belgium	1,657	90
51. Mont Cenis Tunnel	5,280	93
52. La Chapelle, St. Denis, near Paris ...	2,065	94·3
53. Przibram Mines, Bohemia	1,100	107
54. Chanarcillo Mines, Chile, mean	930	129·6
55. Booth Waterworks, Liverpool	560	131
56. Przibram Mines, Bohemia	1,832	135
57. Minas Geraës Mines, Brazil, mean ...	318	157·2

The average rate deducible from all the results given in the above table is 1 deg. Fahr. per 64·28 feet of descent; but all the observations recorded are by no means of equal value, as will be readily understood when the various modes adopted by the different observers, and the specially favourable or unfavourable conditions of time, place, or surroundings, come to be considered. Moreover, the rates shown in the Table are taken from the reading at the deepest point to which no accidental error seems to attach, and from the assumed mean annual temperature at the surface in each locality. In almost every case many intermediate readings could be given which would materially alter the average. Of these intermediate readings some are very abnormal, and evidently due to accidents of various kinds, some of which can be explained away and some not. The full readings can, most of them, be found in the Reports of the British Association Committee on Underground Temperature, where they are discussed by Professor J. D. Everett, F.R.S., the able Secretary to the Committee.*

In estimating the relative value to be attached to the rates of increase given in the Table, perhaps the most important point to be considered is the method pursued in obtaining the thermometric readings from which they are deduced.

All the observations were taken either in water or in air.

Those taken in water may be divided under two heads, viz., where the water was in wells or shafts and other workings in mines, and where the water filled boreholes.

Where the water was in shafts and other workings of mines, some of the observations were taken where the water was stagnant, others where the water was running, *i.e.* of the nature of a feeder.

* See British Association Reports from 1867 to the present time. When it first entered upon its labours the Committee consisted of the following members:—Sir William Thomson, F.R.S.; E. W. Binney, F.R.S.; Principal Forbes, F.R.S.; A. Geikie, F.R.S.; James Glaisher, F.R.S.; Rev. Dr. Graham; Professor Fleeming Jenkin, F.R.S.; Sir Charles Lyell, Bart., F.R.S.; Professor J. Clerk Maxwell, F.R.S.; G. Maw; Professor J. Phillips, F.R.S.; W. Pengelly, F.R.S.; Professor Ramsay, F.R.S.; Professor Balfour Stewart, F.R.S.; G. J. Symons; Professor James Thomson; Professor J. Young; and Professor J. D. Everett, Secretary. In 1881 the Committee consists of:—Sir William Thomson, F.R.S.; G. J. Symons, F.R.S.; Sir A. C. Ramsay, F.R.S.; Professor A. Geikie, F.R.S.; James Glaisher, F.R.S.; W. Pengelly, F.R.S.; Professor E. Hull, F.R.S.; Professor Prestwich, F.R.S; Dr. C. Le Neve Forster; Professor A. S. Herschel; Professor G. A. Lebour; A. B. Wynne; W. Galloway; Joseph Dickinson; E. Wethered; and Professor J. D. Everett, F.R.S., Secretary.

The object of the investigation in all cases being to find the temperature of the rock at certain depths, it becomes important to know how far that of water stagnant within walls of rock, wide apart as in mines, or narrow as in boreholes, or issuing from the rock in form of springs, can be regarded as corresponding with it. As to this the most diverse opinions have been held by high authorities. Sir William Thomson says:—"All sound naturalists agree that we cannot derive accurate knowledge of underground temperature from mines; but every bore that is made for the purpose of testing minerals gives an opportunity of observation."* The late Professor Phillips said:—"It is in the solid rock that the best observations, and those most suited to the purpose of philosophical reasoning, are to be obtained."† On the other hand, Fox and Henwood, to whom is owed more actual work on the subject than to any other *savants*, thought differently, the former saying, "I am disposed to attach most importance to observations on springs of water not coming from the roofs of galleries, or evidently proceeding from higher parts of the mines;"‡ whilst Mr. Jory Henwood, who may be said to have tried all methods, concludes:—"After most careful consideration of the subject, and consultation with others who have also been engaged in this inquiry, it has been thought best to confine the observations as much as possible to the temperature of the streams of water immediately issuing from the unbroken portions of the rocks and veins."§ As Mr. Henwood proceeds to show, the temperature of the air of mines is affected by a number of factors which tend to render it very different from that of the rock, and that water flowing through or standing in pools in the levels is exposed to the same modifying causes.

The modifying causes alluded to—the presence of workmen, combustion of candles or lamps, ventilation currents, etc.—do not affect boreholes where convection of the water filling them, and the possible ingress of abnormally warm or cold springs, are the chief vitiating agents. Accordingly, among the observations taken in water, it would appear that those in bore-holes may *a priori* be presumed to yield the most trustworthy results.

But although it is probably right to view observations of temperature in the ordinary air of open mines with considerable suspicion, the case is much altered when they are taken in holes, even of shallow depth, driven

* Transactions of the Geological Society of Glasgow, Vol. III., Part 1, sec. 29.

† Reports of the British Association, Vol. V., page 292 (1836).

‡ Transactions of the Royal Geological Society of Cornwall, Vol. III., page 320.

§ Transactions of the Royal Geological Society of Cornwall, Vol. V., page 387.

from the walls or roofs of mines, and carefully plugged off from the workings. Indeed, such observations are amongst the best that have been recorded.

It does not come within the limited scope of this paper to detail all the observations mentioned in the preceding list, but in three cases this will be done, each being selected as typical of a method of procedure, and for having been carried on at a considerable depth with exceptional care by excellent observers.

The first case is typical of the wet-boring process pure and simple.

The second is typical of the wet-boring process with special appliances for reducing or doing away with the effects of convection.

The third is the best example of observations in dry short borings from mine workings.

The details given will, moreover, illustrate very clearly some of the difficulties met with in investigations of this kind.

The first case is that numbered 31 in the Table. The observations were made in 1872, at the writer's request, by Mr. J. B. Atkinson, for the British Association Committee, in a bore two and a half inches in diameter sunk from the bottom of South Hetton Colliery, Durham. A protected Negretti thermometer was used. The following figures are quoted from the Fifth Report of the Committee, British Association Report for 1872, page 133 :—

TABLE II.

Depth from Bottom of Shaft.	Depth from Surface of Ground.	Temperatures observed during Boring in April, 1869.	Temperatures observed in April, 1872.
Feet.	Feet.	Deg. Fahr.	Deg. Fahr.
100	1,166	...	66
200	1,266	...	68¾
288	1,354	72	...
300	1,366	...	70
400	1,466	...	72
500	1,566	...	74½
582	1,648	82	...
600	1,666	...	76½
644*	1,710	...	75 †
670	1,736	...	77½
858	1,924	96	...

* The hole below this point was full of sludge, but the next recorded depth was reached by the thermometer by attaching a spike to its metal case.

† When repeated, at a later period, this reading was found to have been accidental, being probably caused by insufficient time having been allowed to the thermometer. A normal reading between 77 and 76 deg. should be substituted. See Sixth Report, 1873, page 254.

Still quoting Professor Everett's Report (page 133):—"The following are the rates of increase deduced from Mr. Atkinson's observations, omitting the temperature 75 deg. at the depth of 644 feet:—

Depth in Feet.	Increase in Degrees.	Feet per Degree.
100 to 200	2¾	36
200 to 300	1¼	80
300 to 400	2	50
400 to 500	2½	40
500 to 670	1⅝	62
600 to 670	1	70
100 to 670	11⅛	51·2

"The average increase between the depths of 100 feet and 670 feet is 1 deg. in 51·2 feet. These depths are reckoned from the top of the bore-hole, which is 1,066 feet below the surface of the ground. Mr. Lebour assumes that the temperature at the depth of 60 feet from the surface of the ground is 48 deg. Accepting this estimate, we have a difference of 29⅛ deg. in 1,676 feet (1,066 + 670 − 60 = 1,676), which is at the rate of 1 deg. in 57·5 feet."

The rocks were of the ordinary coal-measure kind; repeated alternations of sandstone, shales, coals, and fire-clays.

The second example chosen, number 15 in the list, is one which has created a large amount of interest on account of the great depth of the bore, the unusual pains which had been taken with the observations, and the apparently abnormal character of the results. This is the recent case of the celebrated boring at Sperenberg, near Berlin, which reached a depth of 4,172 feet. The writer had prepared a *résumé* of the temperature observations at Sperenberg based upon the British Association Report for 1876; but since the reading of the present paper a work of the highest interest has been published by the Rev. O. Fisher, F.G.S., in which the figures in question are given in what appears a still clearer form.*

* See "Physics of the Earth's Crust," by the Rev. Osmond Fisher, M.A., F.G.S., 8vo, London, 1881 (December), page 10.

The writer, therefore, has no hesitation in substituting this Table for his own :—

TABLE III.

Depth in Feet.	Temperature in R. Degrees.		Water shut off. Consequent Alteration in Temperature.	Surface temperature, 7·18 deg. Absolute Increase at each Depth in Col. 2.	Being at the rate of 1° R. per Number of Feet.	Absolute Increase at Depths.	Being at the rate of	
	Water shut off.	Water not shut off.					1° R. per Foot	1° F. per Foot.
15	9·40	10·35	− 0·95	...	...	...	...	...
30	9·56	10·20	− 0·64	...	...	...	...	...
50	9·86	10·40	− 0·54	...	...	...	...	...
100	10·16	12·30	− 2·14	2·98	33	...	...	...
300	14·60	13·52	+ 1·08	4·44	45	...	...	...
400	14·80	14·30	+ 0·50	0·20	500	...	...	...
500	15·16	14·68	+ 0·48	0·36	277	...	...	...
700	17·06	16·08	+ 0·98	1·90	105	...	...	...
900	18·50	17·18	+ 1·32	0·44	455	...	...	...
1,100	19·90	19·08	+ 0·82	1·40	143	11·72	94	42
1,300	21·10	20·38	+ 0·72	1·20	166	...	...	...
1,500	22·80	22·08	+ 0·72	1·70	118	...	...	...
1,700	24·10	22·90	+ 1·20	1·30	154	...	...	...
1,900	25·90	24·80	+ 1·10	1·80	111	...	...	...
2,100	27·70	26·80	+ 0·90	...	111	7·80	128	57
2,300	28·50	28·10	+ 0·40	1·80	250	...	...	...
2,500	29·70	29·50	+ 0·20	1·20	166	...	...	...
2,700	30·50	30·30	+ 0·20	0·80	250	2·80	214	95
2,900	...	31·60	...	...	...	...	...	...
3,100	...	32·70	...	...	...	...	...	...
3,300	...	33·60	...	...	...	...	...	...
3,390	36·15	34·10	+ 2·05	5·65	122	...	...	...
3,500	...	34·70	...	...	...	...	...	...
3,700	...	35·80	...	...	...	...	...	...
3,900	...	36·60	...	...	...	...	...	...
4,042	38·25	38·10	+ 0·15	2·10	310	7·75	212	95

In this Table the feet are Prussian feet, the difference between them and English being so small as to be immaterial.

The facts given in this Table are very remarkable, and a full discussion of them will be found in the British Association Report, already referred to, where Professor Everett, after making every correction for pressure, etc., arrives at 1 deg. Fahr. per 51·5 English feet as the mean rate of increase to 3,390 feet. In his book Mr. Fisher gives good reasons for regarding the actual rate of increase as rather higher.* For the purposes of this paper, however, the chief interest of the Sperenberg results lies in the fact that an apparatus was in this case successfully used to isolate the thermometer in the bore full of water, and (to a great extent) to stop or impede the action of convection. An inspection of columns 2, 3, and 4 will show how great and how varied, and consequently how difficult to allow for, is the influence of this action in experiments of this kind.

* *Op. jam cit.*, page 16.

The third selected example consists of observations taken for the Committee, at the writer's request, at Boldon Colliery, near Sunderland, in 1875, by Mr. Matthew Heckels, then manager of the colliery.

In this case special vertical bores some ten feet in length were made from the roof of a quiet part of the workings, and the thermometer was thrust up these holes attached to a stick, the holes being carefully plugged up, and the instruments left for several days, and only taken down to be read from time to time.

The observations were taken at 1,365 and 1,514 feet from the surface. The temperature at the former depth was 75 degs. Fahr., at the latter 79 degs. This would give 4 degs. increase for 149 feet; but reckoning from surface mean temperature, which here may be assumed as being 48 degs. Fahr., a much more normal rate is obtained, viz., 1 deg. Fahr. in 49 feet.

Indeed, nothing is more striking than the fact that, in by far the greater number of *good* sets of observations, the mean rates of increase cluster about the numbers 1 deg. Fahr. per 50 or 60 feet.

Professor Everett seems to give the preference to 1 deg. per 56 feet;* the Coal Commission of 1870, with considerably less data than are now available, accepted 1 deg. per 60 feet; and Mr. Fisher takes 1 deg. per 50 to 60 feet as the average.

That practically is the result arrived at by most of the observations which do not appear to be vitiated by untoward conditions. The chief amongst the latter will be now briefly considered.

First, as regards observations in water. In shafts, stagnant water is liable to variations of temperature according to the seasons even at a considerable depth, and after rainfall or drought. This is well shown in the observations taken by Mr. David Burns, F.G.S., in some of the Allenheads mines (Nos. 3, 6, 36 in Table I.) Discrepancies of this kind were also met with in the upper or "well" portion of the Kentish Town hole, as shown by Mr. Symons' results (Nos. 18, 19, 21 in the same Table). But the chief objection is the wholesale convection which is inseparable from such wide columns of water.

In boreholes of considerable depth the effects of changes in surface temperatures are practically *nil*. Convection is here, however, still a constant source of error. However narrow the bore, convection takes place, and, as a result, thermometric observations taken in them give, not the temperature of the rock at certain depths, but that of the moving water at those depths. Now, if the rock in which the hole is bored is of the same

* See Proceedings of the Belfast Natural History and Philosophical Society for 1873-74.

kind from top to bottom, it might be assumed that the convection currents set up by the heat below are uniform, and some correction of sufficiently general application might be used to convert the readings into true rock temperatures. But, as a rule, a bore passes through very numerous beds of rock of various kinds. Each kind has a special rate of heat-conduction of its own, and the changing conductivities become disturbing elements as regards the convection of the water. Knowing the absolute conductivity for heat of the various kinds of rock, it might be possible to discover the exact amount of effect produced at each horizon upon the convection currents, but the necessary calculations have not yet been made.

A more practical way of lessening the errors due to convection is that of plugging the hole both above and below the thermometer used. In the Sperenberg observations above recorded a very elaborate form of plug was used, which gave very satisfactory results; but its expense, and the amount of trouble required to work it, would preclude its use in most cases, more especially as bore-rods are necessary for its application. Besides, the Sperenberg bore, being for nearly 4,000 feet entirely in rock salt—*i.e.* enclosed in walls of homogeneous conductivity for heat—comes under the head of exceptional cases. Sand bags have been used as plugs, and so have India-rubber discs arranged along the wire supporting the thermometer in a considerable number of series. An umbrella-shaped plug, collapsing and expanding by means of a double wire, was devised by the writer for this purpose, and another, also by him, necessitating but a single wire, and acting on the same principle as a safety-cage, viz., falling freely so long as the wire remains taut, expanding and gripping the sides as soon as the wire is let go. To all these appliances there are objections in practice, and so far, the Sperenberg observations remain the only really successful ones with plugs for stopping or checking convection.

Springs or feeders of water at various horizons in a bore are a source of error, which must be of very usual occurrence, and which it is almost impossible to guard against. In some districts such springs may have, as Mr. Henwood held, practically the same temperature as the bed of rock from which they issue, and the error due to them may be correspondingly small, but often the feeders may be of much higher temperature, and must vitiate all readings taken in their vicinity. In the case of Mr. Henwood's Cornish observations, all of which were taken in springs issuing at various depths in mines, their great number, and the care and judgment with which they were selected and carried out, give great

weight to the means deduced from them. Thus No. 7 in Table I. is the mean of 415 observations of this kind. They were distributed as follows among the principal mining districts of Cornwall and Devon :*—

TABLE IV.

Districts.	Mean Depth in Feet.	Mean Temperature Fahr. in Degrees.
Saint Just	570	57·84
Saint Ives	774	63·56
Marazion	456	63·87
Gwinear, etc.	606	63·4
Helston	804	66·66
Camborne, etc.	588	62·13
Redruth, etc.	792	71·37
Saint Agnes	594	65·91
Saint Austell	816	70·62
Tavistock, etc.	432	59·07

It is, of course, very necessary to be able to know exactly at what depth the thermometer employed in taking borehole temperatures is standing. This would seem at first sight to be a very easy matter; but in practice much annoyance is caused by the lengthening—unequal lengthening the writer has more than once found it to be—of the wires used to suspend the instrument. A drum coupled with a mechanical counter is the most useful form of apparatus for lowering and raising thermometers in bores, the best wire for the purpose being pianoforte wire, which is much less liable to changes of length than the copper wire generally employed. (A drum of this kind, designed by Mr. Lindsay Galloway for the use of the British Association Committee, was exhibited to the meeting.)

Formerly, self-registering thermometers were commonly used, but the shaking, which it is all but impossible to avoid in raising them from any great depth in narrow bores, was so apt to displace the index that they are now given up. The instruments now recommended are of the type of Negretti and Zambra's so-called "mining thermometer," where the bulb is surrounded by a non-conducting substance, usually paraffin. Very slow action is thus ensured, and, after being left a sufficient time at any particular depth to mark the degree of temperature at that horizon, the mercury will remain practically stationary during the short time necessary to haul up the instrument.

Attention has already been called to the conductivity for heat of various rocks, as affecting the convection currents in the water filling

* See Cornwall Geological Transactions, Vol. V., page 402.

boreholes. The actual rate of increase of temperature in going downwards depends upon this same conductivity, such increase being more rapid as the index of conductivity is lower, slower as the rocks are better conductors. But it has been found that the index of conductivity of a rock when dry is very different from that exhibited by the same rock when wet; the latter offering far less resistance to the passage of heat than the former. This makes another source of error pertaining to observations in wet bores which should not be lost sight of.

The conductivity for heat of fissile or laminated rocks also varies according to the position of the laminæ with regard to that of the source of heat. Rocks of this kind, when vertical, conduct heat more rapidly than when horizontal, when dipping than when flat. Here there is another source of error due to conductivity. This one, like the last, can probably be fairly corrected, so far as shallow depths are concerned, now that the absolute conductivities of so many rocks are known, thanks to the arduous labours of Prof. A. S. Herschel,* only recently completed. But at great depths the rocks are no longer at ordinary temperature, and it is not to be assumed that at very high temperatures the index of conductivity for heat of any substance will be the same as at comparatively low ones. For errors possibly due to this cause there is as yet no correction, experiments on this portion of the subject being still a desideratum.

Connected with the general low conductivity for heat of most rocks is the extraordinary time required before the heat due to boring operations is lost in bores of considerable depth, be they wet or dry. Many most carefully conducted observations have been rendered valueless from being made too soon after the boring tools have been removed. There are few exact data on this subject at present, but Mr. W. Galloway is now investigating it for the British Association Committee. It is, however, proved by many sets of readings (*e.g.* Nos. 31, 41, 52 in Table I.) that, under certain conditions, months may elapse before the water or air at the bottom of a deep bore regains a temperature at all representing that of the surrounding rock. This is a point on which persons practically acquainted with boring might give exceedingly valuable information. Even in the short hand-bores used in dry-air observations of the Boldon Colliery type a certain amount of time must be allowed to elapse before readings are taken.

The form of the surface should be considered in estimating the value of temperature observations taken even at great depths below it. A point in the ground vertically under a steep crest is more exposed to the

* See Reports of the British Association on Rock Conductivities, 1874 to 1882.

cooling influence of the air than a point at the same depth beneath a plain. The decrease of temperature upwards is about three and a half times more rapid in the air than in the rock, and the curves of the planes of equal temperature below ground will therefore necessarily be affected by the greater or less degree of convexity in the great surface features of the ground above. This is a point which must chiefly be kept in view in discussing observations taken in mountainous regions, such as those in short dry bores in the Mont Cenis, St. Gothard, and Hoosac Tunnels, in all of which very elaborate series of experiments on subterranean temperature have been and are being made (No. 51 in Table I.)

Many years ago Reich called attention to a belief held by the miners in Saxony that tin mines were colder than others.* In mines containing much pyrites the reverse is the case. In the mines on the Great Comstock lode, as every one knows, temperatures abnormally high are found —so abnormal indeed that they have been omitted from the Table in the present paper as being useless for comparisons with ordinary readings. Temperatures, not so unusually great as those of the Comstock lode, were found in the Schemnitz mines, in Hungary (43 to 47 in Table I.); others, also very irregular, in some bores in the immediate neighbourhood of lead veins in North Wales, taken recently with great care by Mr. Strahan of H.M. Geological Survey. Examples of this sort might be multiplied, showing that in connexion with mineral veins a normal or regular rate of increase of temperature is not to be counted on. What this may be due to it is not always easy to say, but with the facts before us it seems fair to conclude that chemical action is at the root of the matter. The decomposition of the metallic sulphides, which form the greater part of the mineral contents of most metalliferous veins, give rise to great heat. Some hot mineral springs are traceable to this cause. Other chemical decompositions may cause a lowering of the temperature at certain points within the interior of the earth's crust. To be on the safe side, therefore, it is necessary to exclude, or at any rate receive only with diffidence, all observations taken in the neighbourhood of mineral veins, when such observations are abnormal in character. When, as in the case of Mr. Henwood's remarkable series of experiments mentioned above, the results show no violent difference from those in regularly-bedded and unfaulted districts, it may be accepted then as a proof that chemical decomposition is working there but on a very small scale.

Again, there is no reason to assume that movements of the earth's crust

* Beobachtungen ueber die Temperatur des Gesteins in verschiedenen Tiefen in den Gruben des Sachsischen Erzgebirges, p. 87.

are now dead. Upheaval, sinking, and lateral squeezing of the rocks are still, no doubt, slowly going on now as formerly, and where such mechanical action exists there also will abnormal heat be evolved, and there will thermometric observations, as in the case of metalliferous districts, be vitiated by the fact that the heat registered may not be that of the great central hot kernel of the globe (to the existence of which every geological phenomenon points), but may be merely due to the fact that some of the many minor local foci of heat are being approached which chemistry and physics demonstrate must be found where certain chemical and mechanical actions are taking place.

As to what remains to be done in order to improve the present knowledge of the rate of increase of underground temperature, observations in coal mines under the sea have been pointed out by Professor Everett as likely to yield important results, and the assistance of members of the Institute is asked in this direction, as well as in any other which may be suggested to them by their practical knowledge of mines and mechanical appliances. The chief desiderata have been enumerated one by one as each chief source of error has come under notice.

In conclusion, the writer begs to disclaim any pretensions to originality in the present paper, nothing in which is new but its arrangement, and perhaps some of the views as to the worthlessness of certain observations.

The PRESIDENT said, the members would join with him in passing a vote of thanks to Professor Lebour for the paper he had read. The heat of underground strata was a subject which affected deep mining very much indeed, and, of course, as years went on, and the upper beds of coal were worked off, this subject would affect them much more. He was sure that the members of the Institute would be glad to co-operate with Mr. Lebour in obtaining such information as he desired. So far as he was concerned, he could promise the Professor a series of observations under the sea.

Mr. BEWICK hoped that Mr. Lebour would, in the tabular statements embodied in his paper, give the geological formation in which the observations were taken. Allusion had been made to the temperature in some observations made at Allenheads, but the results would depend upon the period of the week at which they were taken. A large number of men and some horses were employed, and powder was exploded; all which would tend to cause some variation according to the time at which the

observations were made. Then, again, the proximity of veins would be an interesting matter to consider. There were a great many veins of different characters, containing lead, zinc, and copper ores, pyrites, and other matters; these and even the direction of the wind might affect the observations taken at Allenheads.

Professor LEBOUR said, he would give the geological formations in which the observations were taken when they were known; some of those who had taken the other observations had been careless. He believed the observations at Allenheads were taken in shafts under water. The shafts were the High Underground Engine Shaft and the Gin Hill Shaft; and he mentioned these observations to show the difference after a drought and after rain. The observations in the shafts at Allenheads were taken by Mr. D. Burns, F.G.S., in water in 1871. Otherwise he thought these observations in shafts were almost worthless.

Mr. BEWICK—Both the shafts mentioned are working shafts, and the observations must have been taken in the sump-hole.

Mr. BOYD said, one circumstance had struck him forcibly, namely, whether the increased temperature was entirely due to the superincumbent strata, or whether the sea level had any influence upon it. For instance, in piercing the Mont Cenis tunnel a temperature of 90 degs. was observed, which was considerably more than that obtained at depths very much nearer to the centre of the earth.

Mr. COOKE asked Professor Lebour whether the increased temperature might be due to heat being rendered sensible which had been latent on account of the compression in great depths, either in water, or air, or solid rock, that is, in fact, whether the pressure has anything to do with the increasing heat? He reminded them of the popular lecturer setting fire to tinder by the sudden compression of air in a cylinder, and of the necessity of cooling appliances, where air-compressing engines are used.

Professor LEBOUR said, pressure by itself could not develop heat. It was only where motion was destroyed as motion that it was converted into heat. Therefore, there was no reason for imagining that increase of temperature as descent was made below the earth's surface could be due to the pressure of the overlying rocks, or "cover."

Mr. BIRD asked Professor Lebour if there were not instances of variation in the same borehole. If there was a borehole 3,000 feet deep, was not the rate of increase different at the first thousand, and at the second thousand, and at the third thousand?

Professor LEBOUR said, Mr. Bird had touched upon a point which was the very pith of the whole matter. These differences in the increase

of temperature were among the difficulties of the observations. He did not know of any observations where they did not get differences of this kind. If they took two or three cases where there were observations every 50 or 100 feet, and took the difference between the temperature at 100 feet, and the temperature at the lowest depth (unless an abnormal one), they would find that the mean was something like 1 in 56 in most instances. Between those two they found great variations of all kinds in the rate: they sometimes found even decrease, and not increase. He cast aside all minor matters because they interfered with the general results which seemed to be generally established. If anyone would study the minor matters, and give the result of his observations, he would do great service to science. It was almost impossible for anyone not acquainted with localities to explain carefully the discrepancies in each case. If people connected with a locality would attend to the facts of that locality, they would do great service.

Mr. Bird understood Mr. Lebour to mean that if these matters were eliminated the rate of increase would be found to be uniform in one place, with a few exceptions.

Professor Lebour said that was so.

Mr. Boyd proposed, and Mr. Bird seconded, a vote of thanks to Mr. Lebour for his most interesting paper, which was unanimously carried, and the discussion was adjourned.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 11TH, 1882, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. B. FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

ABSTRACTS OF FOREIGN PAPERS.

The following report by the SECRETARY was read:—

Having been asked to report generally as to the mode by which extracts from American and other foreign publications can be abridged, translated, and printed in the Transactions of the Institute, I respectfully submit the following suggestions for your consideration.

That a space, to be determined by the Council, of the Transactions, printed in small type, be devoted to such extracts.

That the extracts shall not be continuous extracts or translations of the articles noticed, but simply terse abstracts of the principal points of the paper.

That each such extract shall on no account exceed three pages.

The remuneration for the extracts not to exceed 12s. 6d. per page; fractions of a page in proportion.

For the present the extracts shall be limited to three classes, namely, Mining and Mining Appliances, Geology, and Machinery.

That the selection of the works to be abstracted shall be left with three members, each conversant with the subject allotted to him, to be elected from time to time.

That these three gentlemen shall be authorised to employ such assistance as they may think necessary.

That they shall send to the Secretary from time to time every year, all such abstracts as they wish to appear in the Transactions, together with the names of the actual abstractors.

These abstracts to be edited by the Secretary, and published in the Transactions with the initials of the translator or abstractor.

No plates to be allowed, and no extracts to be printed after a lapse of eighteen months from the date of the publication of the original article.

The PRESIDENT said that, in accordance with that report, which had been passed by the Council, Professor Merivale, Professor Lebour, and Mr. Newall had been kind enough to undertake to select the articles to be abstracted, and appoint suitable abstractors, and he thought the abstracts would be of great service to the members of the Institute.

The following gentleman was then elected :—

ASSOCIATE—

Mr. JOSEPH FARROW, Brotton Mines, Saltburn-by-the-Sea.

The following were nominated for election at the next meeting:—

ASSOCIATE—

Mr. GEORGE N. VITANOFF, Messrs. Hawks, Crawshay, & Sons, Gateshead.

STUDENT—

Mr. FRANCIS W. GREEN, Harton Colliery Offices, South Shields.

Mr. W. J. BIRD read the following paper "On the Comparative Efficiency of Non-conducting Coverings for Steam-pipes:"—

THE COMPARATIVE EFFICIENCY OF NON-CONDUCTING COVERINGS FOR STEAM PIPES.

By Mr. W. J. BIRD.

In September, 1879, the writer had the honour of reading before this Institute a paper on "Condensation in Steam Pipes," showing how this was effected by the use of a non-conducting covering. Since that period, further experiments have been made to test the efficiency of non-conducting coverings, and it is to compare the results of these that this paper has been drawn up.

It will, perhaps, be best to commence with a description of the various non-conducting materials which were subjected to experiment.*

Silicate cotton, or slag wool, as it is sometimes termed, is made from blast furnace slag by forcing steam or air through it when in a molten condition. It is free from organic matter and quite incombustible. In its normal condition one cubic foot weighs about 12 lbs., and the cost of the material as applied to steam pipes is stated to be 2d. per square foot for each inch in thickness of covering.

1. It was tried enclosed within wood lagging or canvas, and also in external tubes made of strawboard or sheet iron.

2. When made into mattresses which are sewed closely together over the surface to be protected. A coating of tar or paint over all is recommended.

3. Applied in the form of a cement, which is made by mixing up the silicate cotton with a thick clay wash. In this state, however, it is not such a good non-conductor. In the experiments, silicate cotton was tested without any covering, being merely placed on the pipe and wrapped round with cord.

4. Toopes' patent covering is composed of an inner circle of asbestos, backed with compressed paper and two outer circles of the same material. Hair felt is interspersed between these layers, and the outside of all is black-varnished. It is made about three-quarters of an inch in thickness, and shows extremely good results; its cost is high, tenpence-halfpenny

* Samples of these materials were laid upon the table for the inspection of members.

per square foot, but it requires little labour to attach it to the pipes. It stands very well in a dry situation, but soon suffers from wet. An outside coating of tar would be an advantage in these cases.

5. A patent composition of a plastic and fibrous nature. It is first mixed with water and then plastered on to the steam-pipe to the desired thickness. It soon dries, and remains firmly attached to the pipe. It should be coated with tar on the outside, and it is advantageous to encase it in iron wire netting. Its cost is £2 15s. per ton, and at the thickness of $1\frac{1}{2}$ inches the cost per square foot is about threepence-farthing.

6. Hair felt was also tested. A sheet three-quarters of an inch in thickness was applied to the steam pipe. The cost may be taken at threepence-halfpenny per square foot.

The steam-pipes on which the experiments were made were of two sizes—$2\frac{1}{2}$ inches and $10\frac{5}{8}$ inches external diameter each. On the small pipe silicate cotton, silicate cotton mattress, and silicate cotton cement were applied three-quarters of an inch thick. On the large steam-pipe silicate cotton and the patent composition were applied $1\frac{1}{2}$ inches thick, while Toopes' patent covering and hair felt were put on only three-quarters of an inch thick.

Observations were made of the temperature of the outside of these coverings. On the bulb and as much as possible of the tube of the thermometer a screen of felt was placed to cut off the cooling effect of the wind. The temperature of the air was observed by a second thermometer, and the temperature of the uncovered pipe was deduced from the steam-pressure with a small correction for the thickness of iron in the pipe. The observations were as follows :—

TABLE I.

Name of Material.	Small Pipe (2·5 Inch).				Large Pipe (10·6 Inch).			
	Thickness.	Temp. in Deg. Fahr.			Thickness.	Temp. in Deg. Fahr.		
		Pipe.	Air.	Diff.		Pipe.	Air.	Diff.
— Uncovered pipe	...	252	42	212	...	251	67	184
1. Silicate cotton	$\frac{3}{4}$	134	42	92	$1\frac{1}{2}$	126	67	59
2. Silicate cotton mattress ...	$\frac{3}{4}$	108	42	66	...	...	...	...
3. Silicate cotton cement ...	$\frac{3}{4}$	165	41	124	...	...	...	...
4. Toopes' patent covering ...	$\frac{3}{4}$	85	42	43	$\frac{3}{4}$	111	67	44
5. Composition	...	...	...	...	$1\frac{1}{2}$	124	67	57
6. Hair felt	...	...	...	...	$\frac{3}{4}$	142	68	74

The heat loss of these steam pipes is due partly to radiation, to surrounding objects, and partly to contact with colder air. The loss is estimated in units of heat, one unit being the amount necessary to raise one pound of water 1 deg. Fahr.

In ascertaining the loss by radiation it must be observed that the radiating power of bodies depends on the nature of their surface. This power has been ascertained by experiment on many substances. Suppose R to be the radiating power in units of heat emitted per square foot per hour when the radiating body has an excess of temperature of 1 deg. Fahr., then, for ordinary atmospheric temperatures, and for small excesses of temperature in the radiating body, it may be assumed that the heat loss is simply proportional to the difference, but for considerable excesses of temperature the heat loss is much greater; that is, the heat loss increases in a greater ratio than the excess of temperature increases. This ratio has been investigated by Dulong and determined by him for various temperatures. Now let R be the heat units emitted per square foot per hour for an excess temperature of 1 deg. Fahr.; D the excess of temperature in deg. Fahr. of the radiating body over the absorbent; and r the ratio in which the heat loss increases with the increase of D; then $R \times D \times r$ is equal to the loss of heat by radiation in heat units per square foot per hour.

The loss of heat by contact of air is independent of the nature of the surface, but depends on its shape. It differs, as the heated surface is a plane, a sphere, or a cylinder. Suppose A to represent the heat units lost per square foot per hour for an excess temperature of one deg. Fahr.; this quantity has been experimentally determined for cylindrical bodies, such as pipes, and it differs with their diameter, A being less in a large pipe than in a small one. For small excesses of temperature the heat loss is simply proportional to that excess, but with large excesses of temperature Dulong has shown that the heat loss increases in a higher ratio; and he has determined this ratio for various temperatures. Thus, let A be the heat units lost per square foot per hour for an excess temperature of one degree Fahr.; D the excess of temperature of the pipes over the surrounding air; and r' the ratio of increase of loss; then $A \times D \times r'$ is the total heat loss per square foot surface per hour from contact of air.

Thus $R \times D \times r$ is the heat loss per square foot per hour from radiation, and $A \times D \times r'$ is the heat loss per square foot per hour by air-contact; and if these quantities are added together, the total heat loss in heat units per square foot surface per hour will be arrived at. As the dimensions of the steam pipes are known, it is easy to calculate the heat loss per foot length of pipe per hour. By comparing the heat

loss of the covered pipe with that of the uncovered pipe, the percentage of heat retained by the covering may be found, and this expresses the comparative efficiency of the non-conducting coverings tested.

TABLE II.

Material.	Small Pipe				Large Pipe.			
	Thickness.	Heat Loss Units per Hour.		Per Cent.	Thickness.	Heat Loss Units per Hour.		Per Cent.
		Per Square Foot.	Per Foot Length.	Efficiency.		Per Square Foot.	Per Foot Length.	Efficiency.
— Uncovered pipe	...	514·3	336·6	...	...	357·7	990·8	...
1. Silicate cotton	¾	157·1	164·5	51·1	1½	89·9	320·0	67·7
2. Silicate cotton mattress	¾	107·7	112·8	66·5	...	...	...	...
3. Silicate cotton cement ...	¾	248·6	260·3	22·7	...	...	...	...
4. Toopes' patent covering	¾	65·2	68·3	79·7	¾	66·4	208·5	78·9
5. Composition	...	...	...	...	1½	85·7	305·1	69·2
6. Hair felt	...	...	...	...	¾	118·5	372·0	62·3

The percentage of efficiency is calculated from the heat loss per foot length of pipe. It would be erroneous to calculate it from the heat loss per square foot, as the surface is of course larger on the covered than on the uncovered pipe. It will be observed that Toopes' patent covering was applied to both pipes in the same thickness, and the percentage of efficiency is nearly the same, 79·7 and 78·9. Again, the silicate cotton is applied in two thicknesses, ¾-inch and 1½-inch. The ¾-inch cover retains 51·1 per cent. of the heat, while the 1½-inch retains 67·7 per cent. Thus a double thickness, at a more than double cost, only gains 17 per cent. more heat. The silicate cotton in both cases appears to some disadvantage, as it was not enclosed in wood lagging, or canvas, strawboard, or iron tubing, as is recommended. Toopes' patent covering shows really extraordinary results for such a small thickness, and it is only its great cost that hinders its more extensive use. The patent composition ranks between silicate cotton mattress and silicate cotton for efficiency. An enumeration of the materials in their order of merit would stand thus:—(1) Toopes' patent covering, (2) Silicate cotton mattress, (3) Hair felt, (4) Composition, (5) Silicate cotton, (6) Silicate cotton cement.

Having now compared the efficiency of these materials in heat retention, it will be advisable to state the absolute saving effected in each case, and the cost at which it is obtained. Let it be supposed that an engine

plane underground at a distance of 1,000 feet from the boilers at bank has to be dealt with. The steam pipes are 1,000 feet in length and 10·6 inches external diameter, as in Table II. Under the same conditions of temperature, the heat loss on the 1,000 feet would be 1,000 times the loss on one foot. It is true that the pipes in the shaft would lose less heat than the same length in a horizontal position; but that may be considered balanced by the increase of cooling surface in flanges and bolts. Then, to obtain the loss in heat units per hour for the 1,000 feet range, it remains only to multiply the loss per foot length by 1,000. Let it be assumed that one cubic foot of water in the boiler at 60 degrees evaporated to steam at any pressure is equal to one nominal horse-power; then 69,674 heat units is equal to one horse-power (nominal). The loss of horse-power in each case will then be arrived at.

Another column shows the cost of material employed in coating the 1,000 feet length of pipes, and then the cost per horse-power saved is stated. The saving in fuel is also shown. Here it is assumed that each horse-power will require two cwts. of coal per 24 hours, which is perhaps a rather better result than is generally obtained in colliery boilers. The value of the fuel is taken at four shillings per ton.

TABLE III.

Material.	Steam Pipes, 10·6 Inches External Diameter, 1,000 Feet Length.					
	Thickness.	Horse-power.		Cost of Material.		Fuel.
	Applied.	Loss.	Saving.	Total.	Per H.P. Saved.	Saved per Annum.
				£ s. d.	£ s. d.	£ s. d.
Uncovered pipe	...	14·22	...	.....	...	...
Toopes' patent covering ...	¾ inch	2·99	11·23	137 9 11	12 15 9	81 19 7
Composition	1½ „	4·38	9·84	48 4 2	4 18 0	71 16 8
Silicate cotton	1½ „	4·59	9·63	44 10 0	4 12 5	70 6 0
Hair felt	¾ „	5·34	8·88	45 16 3	5 3 2	64 16 6

In looking at Table III. it will be seen how very large a saving is effected by the use of non-conducting coverings. If a comparison of the coverings is made, according to the cost at which one horse-power is saved, they stand in the following order:—(1) Silicate cotton, (2) Composition, (3) Hair felt, (4) Toopes' patent covering. The writer will now briefly review the performances of non-conducting coverings, as applied to the range of steam pipes 1,000 feet long and 10·6 inches in diameter.

Toopes' patent covering applied at a thickness of three-quarters of an inch reduces the heat loss from 14·22 horse-power to 2·99 horse-power—a saving of 11·23 horse-power. At 10½d. per square foot the cost of material for covering the pipes would be £137 9s. 11d., or £12 5s. 9d. for each horse-power saved. Its efficiency is 78·9 per cent. The fuel saved per annum under continuous working of the engine will amount to £81 19s. 7d., which is an annual return of 59·6 per cent. on the capital (cost of materials) expended. Toopes' covering ranks first in efficiency, but fourth in absolute cost, and fourth also in cost per horse-power saved.

The composition, applied to the thickness of 1½ inches, reduces the heat loss from 14·22 to 4·38 horse-power, a saving of 9·84. At 3¼d. per square foot the cost of material comes to £48 4s. 2d., or £4 18s. 0d. for each horse-power saved. Its efficiency is 69·2 per cent. The fuel saved per annum amounts to £71 16s. 8d., equal to an annual return of 149 per cent. on the cost incurred. The composition ranks second in efficiency, third in cost of material, and second in cost per horse-power saved.

Silicate cotton, 1½ inches thick, reduces the heat loss from 14·22 to 4·59 horse-power, a saving of 9·63. At 3d. per square foot the cost of covering amounts to £44 10s. 0d., or £4 12s. 5d. for each horse-power saved. Its efficiency is 67·7 per cent. (The efficiency, at a thickness of ¾ of an inch is 51 per cent.; in the mattress variety, 66½ per cent.; and in the cement variety 22·7 per cent. At 1½ inches thickness the efficiency of the mattress will be 88 per cent., and of the cement 30 per cent.) The fuel saved per annum comes to £70 6s. 0d., an annual return of 158 per cent. on the capital cost of covering. Silicate cotton ranks third as to efficiency, first as to cost of material, and first as to cost per horse-power saved.

Hair felt, in a thickness of ¾ of an inch, reduces the heat loss from 14·22 to 5·34 horse-power, a saving of 8·88. At 3½d. per square foot the cost of covering is £45 16s. 3d., or £5 3s. 2d. for each horse-power saved. The efficiency is 62·3 per cent. The fuel saved amounts to £64 16s. 6d., an annual return of 141·5 per cent. on the capital expended. Hair felt ranks fourth in efficiency, second in cost of covering, and third in cost per horse-power saved.

The writer thinks he has now arrived at a complete and impartial comparison of these non-conducting coverings. No one of them combines all desirable points, and each of them can only be recommended on the balance of its advantages. They all show what may be called good results, and the worst of them is very much better than none. It has

been shown that in a range of steam pipes of any considerable length a very great economy can be obtained at a comparatively small expense, and an uncovered steam pipe should be a very rare sight.

In conclusion the writer would say that he is conscious of many other non-conducting materials left unexamined, but those selected for comparison are well-known substances in extensive use. He will at all times be very glad to receive accounts of further experiments from members interested in the subject.

The PRESIDENT said the subject referred to by Mr. Bird was a very important item in the economical working of collieries, and deserved great attention.

Mr. ROSS said the results shown by Mr. Bird as to silicate cotton were somewhat different to the results obtained at the Paris Exhibition, given in the *Engineer* of March 12th, 1880, page 200. There an asbestos covering of a thickness of 3·15 inches gave a condensation of 0·31 lbs. of water per hour per square foot, whilst a thickness of 2·36 inches of silicate cotton gave a condensation of only ·27 lbs. He thought that Mr. Bird had not conducted his experiments with respect to silicate cotton under the conditions in which it was used. Silicate cotton, being a material something like cotton in appearance, required to have a protecting covering so as to make it effective. The great principle which gave efficiency to the use of silicate cotton, was that it contained air—and air was one of the best non-conductors known. Mr. Bird, by wrapping the silicate cotton round with twine, almost destroyed the advantage obtained by this property, and he thought it would be desirable that experiments should be made with silicate cotton under the circumstances in which the material could be used most advantageously. A small increase in thickness would make a great difference, and the discrepancy between the results now made known and those obtained at Paris might easily be referred to the fact that Mr. Bird experimented with the silicate cotton $1\frac{1}{2}$ inches thick, whereas at the Paris Exhibition the thickness used was $3\frac{1}{3}$ inches. He had tried some experiments by placing pieces of wood against hot pipes protected with this non-conducting material, which proved very clearly the effect of a small increase of thickness of such material. In one case, with 500 degrees of heat, the wood was charred with about 2 inches of material; but when the thickness was increased another inch, the pipe could be heated to 700 degrees,

without the wood being charred. It was true that, with a solid substance, it might fairly be inferred that the benefit arising from an increase of thickness, would not be so great as in a substance like the silicate, which was of a loose nature containing much air between its finely divided fibres; and he thought Mr. Bird might make further observations with advantage. At all events he had made it very clear that there was a very great loss incurred by not covering pipes and boilers.

Mr. COCHRANE said Mr. Bird stated that "It is true that the pipes in the shaft would lose less heat than the same length in a horizontal position; but this may be considered balanced by the increase of cooling surface in flanges and bolts." This he (Mr. Cochrane) could not understand under any circumstances, but especially under the ordinary conditions in which the steam pipe was placed in the up-cast shaft, where the greater velocity of the air would cause a more rapid loss of heat than would take place in a horizontal pipe in a mine.

Professor LEBOUR said that Mr. Bird noticed that silicate cotton was "also applied in the form of a cement, which is made by mixing up the silicate cotton with a thick clay wash; in this state, however, it is not such a good non-conductor." That was only what they had found to be the case with rocks. The experiments which Professor Herschel and himself had carried on as to rock conductivity, all pointed to the conclusion, that generally the more porous the stone the greater the resistance to the passage of heat; moreover, a substance when wet conducted heat better than when dry. He recommended Mr. Bird to give the absolute conductivities resulting from his experiments. It struck him that one point to be considered in the commercial value of these different substances was the length of time they lasted, and that did not seem to have been taken into account. If the covering had to be renewed very often, that must be taken into account in estimating its advantages.

Mr. BIRD said Mr. Ross had remarked that his (Mr. Bird's) experiments did not show identical results to those obtained at the Paris Exhibition. The thickness of the silicate cotton applied in the Exhibition was considerably greater than he used in his experiments. He altogether disputed the fact that adding thickness increased the efficiency of fibrous more than of solid substances. During last week he had made experiments and had tried all these four substances with double the former thickness, and the average result was an increase of efficiency of only 12 per cent. If he had done any injustice to silicate cotton by not surrounding it with an outside covering, this had been more than compensated for by the proportionate lowness of cost, which had of course been very much reduced

in consequence. Mr. Cochrane had drawn attention to a remark about vertical and horizontal cylinders. It was a fact that under the same circumstances of temperature and condition of the air, a vertical cylinder did lose less heat than a horizontal cylinder, on account of the heated air from the lower portion of the cylinder ascending and enveloping the upper portion, and thereby reducing the difference in temperature between the pipe and the air immediately contiguous to it. Mr. Cochrane thought the great velocity of the air in the up-cast shaft would cool the pipes; but that would be generally counterbalanced by the higher temperature of the air in the up-cast shaft, even where mechanical ventilation was employed. He would, however, continue his inquiries and give the absolute conductivity of these substances, all of which were of satisfactory durability.

Mr. Ross said he would like to refer to one discrepancy in Mr. Bird's last remark—that all these substances were of satisfactory durability. In the paper, Mr. Bird set forth that Toopes' material was very much injured by wet—by moisture. That which would not resist wet and heat was not suitable for a boiler covering. They knew that silicate cotton, being composed of blast furnace slag—really a form of glass—was in itself a non-conductor, and, at the same time, impervious to moisture. If a substance was not impervious to moisture, it could not be useful for covering boilers, where there was both heat and moisture.

Mr. Bird said he did remark that Toopes' covering was subject to deterioration in wet situations: but he added that a coating of tar, which was not very expensive, would remedy the evil. Mr. Ross referred to boiler covering. The paper related to coverings for steam pipes.

The President—Have you any absolute data as to how long the coverings will last? That is a very important point.

Mr. Bird said the composition had been exposed for twelve months at the exhaust pipe of a 20-inch cylinder engine, running the better part of the day, in an underground drift, with very little deterioration. Toopes' covering has been used for about the same time, in a dry situation, and stood very well.

The President proposed a vote of thanks to Mr. Bird for his paper, which was seconded by Mr. Cochrane, and carried unanimously.

Professor J. H. Merivale read "An Abstract of an Analysis, by Dr. Chance, of Fire-damp Explosions in the Anthracite Coal Mines of Pennsylvania, U.S."

AN ABSTRACT OF AN ANALYSIS, BY DR. CHANCE,* OF FIRE-DAMP EXPLOSIONS IN THE ANTHRACITE COAL MINES OF PENNSYLVANIA, U.S., FROM 1870–80.

By Professor J. H. MERIVALE.

The following paper may be of some interest to the members as exhibiting data on a most important subject, gleaned from mining experience in America.

"The table, which forms the subject-matter of this paper, is compiled from the reports of the Inspectors of Mines for the years from 1870 to 1879 inclusive. In it are included all recorded explosions, whether resulting in serious or trivial casualties:—

"EXPLOSIONS OF FIRE-DAMP.

	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	Total.
January ...	0	8	3	2	2	3	5	7	2	4	36
February ...	2	4	4	2	5	3	6	4	1	5	36
March ...	0	2	6	3	3	3	4	5	0	8	34
April ...	4	7	14	6	5	2	7	8	2	10	65
May ...	3	10	8	9	8	1	11	9	2	18	79
June ...	1	6	7	13	12	5	4	6	4	3	61
July ...	3	11	5	4	7	7	2	7	4	6	56
August ...	3	10	13	10	5	3	2	3	6	9	64
September ...	4	9	6	10	9	12	4	2	0	10	66
October ...	8	7	10	6	8	6	8	7	2	10	72
November ...	6	3	2	7	9	5	4	7	2	7	52
December ...	6	6	3	2	4	9	8	6	4	10	58
Total ...	40	83	81	74	77	59	65	71	29	100	679

* Read before the American Philosophical Society, May 6th, 1881.

"The table is arranged to show the number of explosions occurring in each month of the year for ten years, and the right-hand column the number for each month of the whole period.

"An inspection of the latter column shows at once that from April to October the number of explosions is far greater than that of the remaining months of the year. In these seven months 463 explosions are recorded, an average of sixty-six for each month; but for the remaining five months we find but 216 explosions, an average of but forty-three for each of these months.

"Temporary or partial suspension of mining during some part of these months in certain years may partly account for this difference, but is inadequate to explain so marked a contrast between the groups of warm and cold months.

"The maximum rate in May, and the next in rank, October, are just five months apart. Are these months subject to greater and more sudden and frequent barometric changes than others in this part of the United States?

"A list of the most serious colliery disasters in Great Britain, from 1778 to 1866 inclusive, develops the interesting fact that, out of forty-five explosions, ten occurred in June and eight in December, periods just six months apart.

"The table is as follows:—

Month.	No. of Explosions.
January	2
February	1
March	4
April	0
May	4
June	10
July	4
August	3
September	2
October	4
November	3
December	8
Total	45

"This list embraces only the explosions resulting in a loss of life of twenty and upwards.

"The occurrence of three of these on June 2nd, 1862, and of two on December the 12th and 13th, 1866, certainly point to atmospheric dis-

turbance as the immediate cause. The occurrence of a large percentage of these disasters at semi-annual periods, June and December, seems to indicate the occurrence in Great Britain during these months of unusually high barometer, followed by a decided fall, as the probable cause of these great outbursts of gas.

"But the problem I have been considering is somewhat different, for the table embraces *all* the explosions, whether large or small, occurring during the ten years. It shows a decidedly larger number for the warm than for the cold months, and, therefore, points primarily rather to impairment of ventilation from high temperature than to barometric changes as the true cause of the difference; but the occurrence of two maximum periods, May and October, seems to indicate that barometric changes have also exercised an important influence on the relative efflux of gas.

"The *amount* of rise and fall does not seem to have a perceptible effect, for the monthly barometric range is *greatest during the cold months*, whereas fire-damp explosions are most frequent during the warm months. Frequent and *abrupt* changes from high to relatively low barometric pressure are the probable cause of many explosions, though the movement of the mercury may not amount to more than one-eighth to one-quarter of an inch. An unusually *high* barometric column is always an intimation of coming danger."

On the other hand, the Belgian Commissioners, in their Report on Colliery Explosions, published in 1880, a copy of which has been kindly lent to the writer by Mr. Walton Brown, do not find that the summer months are more dangerous than the winter. The following table, extracted from their Report (page 218), speaks for itself:—

FROM 1821 TO 1879.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug	Sep.	Oct.	Nov.	Dec.	Total.
Hainault	17	21	28	25	24	20	28	27	24	11	17	26	268
Namur	1	0	1	1	1	0	1	2	1	0	2	2	12
Liége	11	9	21	19	12	8	10	8	6	13	11	4	132
Total of Country...	29	30	50	45	37	28	39	37	31	24	30	32	412

This gives an average per month of 34·2 for the five winter months, and 34·43 for the seven summer months.

The list of explosions appears to include all those that have caused accidents to the workmen, fatal and non-fatal. It will be observed that the table extends over a great many years.

It is impossible to draw up a table precisely similar to that of Dr. Chance from the data collected in the reports of the British Inspectors of Mines, because no notice, except in rare cases, is taken of explosions of gas that have not caused loss of life; but an inspection of these for the the years 1870–79 shows an average of 33 per month for the five cold months, and 39 per month for the seven warm months. It is unnecessary to enter into any details, as the fatal explosions are already collected, tabulated, and published at the end of each volume of the Proceedings.

Mr. Dickinson, in his report for the Manchester district, has, for the twelve years 1869–80, given a list of all the explosions reported to him. On tabulating these an average per month is obtained of 20·2 for the winter months, and 20·7 for the summer.

An examination of the report book of one of the most fiery of the North of England coal mines for the years 1880–81 gives a very different result. Gas was reported 64 times per month during the seven warm months, and 89 times per month during the five cold. Two years is, of course, too short a period to get results of any value, and the writer would like to take this opportunity of asking the managers of fiery mines if they find gas more frequently present during one period of the year than another.

Mr. A. L. Steavenson said it appeared to him that the general result of the statistics was that no particular month or season of the year was more free than another from the chance of accident from gas. The question as to how far barometric changes affected explosions was, to him, a doubtful point. He thought much more depended upon the state of the pit and the management of the ventilation, than upon barometric changes. During the soft muggy days of November he had found ventilation rather short; and before fans were applied, the dull months at the end of the autumn gave some trouble, but that was all.

Mr. Cochrane said that in the earlier part of the paper it was stated that "it shows a decidedly larger number for the warm than for the cold months;" and in the last clause of the paper it was stated that "gas

was reported 64 times per month during the seven warm months, and 89 times per month during the five cold." This appeared anomalous. Generally, he agreed with Mr. Steavenson.

Professor LEBOUR said that the first part of the paper was by the American author, and the last part by Professor Merivale. He imagined the chief object of the paper was to show that the report of Dr. Chance gave no general law of any sort. The moment they looked at the statistics in England they got totally different results. He thought Mr. Steavenson's opinion was the opinion of the majority.

Mr. COCHRANE asked Professor Lebour whether he knew the system of ventilation adopted in Pennsylvania,* and whether they depended upon natural ventilation? He could quite understand that, in such case, in the summer, if gas was given off, there would be greater liability of the air being fouled than in the winter.

The PRESIDENT said this was a subject which would amply repay any discussion. He agreed with Mr. Steavenson that the best course was to keep the pit in good order. He believed the rise and fall of the barometer did exercise an influence on the giving off of gas from old goafs, which acted as gasometers, as it were, and naturally the gas came out when the air was lighter. He did not think it had much effect upon the emission of gas from the bed of coal; and he thought Mr. Lindsay Wood's experiments proved that. He proposed a vote of thanks to Professor Merivale, which was seconded by Mr. Boyd, and passed unanimously.

* It has been ascertained since the meeting that no system of artificial ventilation was generally adopted in the Pennsylvanian Coal-fields.

The following "Description of a New Ventilating Fan," by Mr. T. J. Bowlker, was taken as read:—

AN ACCOUNT OF A NEW VENTILATING FAN.

By T. J. BOWLKER.

The writer wishes to draw the attention of the members of the Institute to an improved fan of the centrifugal type, for which it is claimed that it gives 10 to 15 per cent. more useful effect than the Guibal. Your Committee on Ventilators were applied to about a year and a half ago to experiment on this fan; but, unfortunately, when it was too late for them to do so.

Plate XII., Figs. 1, 2, and 3, show the general arrangement of the fan. *a* is the upcast shaft; *b b* drifts leading to the fan; *c* is the axle; *d* a cast iron diaphragm keyed on to the shaft, and so shaped as to cause the air to be drawn into the fan with the smallest possible loss; *e*, *e* are the curved vanes; and o^1, o^2, o^3 are the three *evasé* openings. In the specification the outer portions (x to y) of these openings are described as hinged at x, so that the opening p, y may be varied at will, in order to ascertain what position it should be in, to give the best results.

It will, perhaps, serve best to show the principles upon which the fan is constructed, and to point out the merits that are claimed for it, to begin by stating the circumstances which led to its construction. The writer will, therefore, adopt this course.

Being located at Rockingham Colliery when a Guibal fan was started, and for some time subsequently, the writer had the opportunity of seeing and assisting in the trying of numerous experiments with that fan The useful effect obtained at the ordinary working speed varied from 40 to 50 per cent. As these results were considerably below what was given as the useful effect in many published experiments, and also below what the theory of the Guibal, as then made known, would lead persons to expect, the writer determined to try and find out whether the great loss of power was a defect arising from some special cause in that particular machine, or was a defect inherent in Guibal fans in general.

In attempting to solve this problem the first thing to be done was to account for the disposal of as much of the horse-power exerted as could be calculated from known data.

In doing this the result of the most satisfactory experiment that had yet been tried was taken. The separation doors being open, at 33 revolutions 165,400 cubic feet of air were obtained with a water-gauge at fan centre of 1·90 inches. The indicated horse-power of engine being 87¼. The fan was 45 feet diameter and 12 feet wide, and the cylinder 36 inches diameter.

From calculations it was estimated that the power was distributed as follows :—

	Horse-power.
Work expended on friction of fan journals, and that arising from the weight of moving parts of engine (hereafter called *weight friction*)	11
Work expended on slide valves, eccentrics, and extra friction, due to steam pressure in the cylinder	9
Work expended in ventilation	49½
TOTAL	69½

Leaving about 18 horse-power, or 20 per cent. of the whole power as loss unaccounted for.

It was at once evident that some of this loss would arise from the friction of the air against the sides of the fan casing, as the air was being turned round and round by the fan; but it was not at first anticipated that this air friction would account for most of this loss.

On first attempting to make a rough calculation of what the air friction would amount to, the writer was not possessed of any other determinations of the co-efficient of friction than those given in Atkinson's "Treatise on Ventilation." That given as determined by Péclet for air rubbing against burnt earth is ·0217 lbs. per square foot of rubbing surface, for a velocity of 1,000 feet per minute.

Using ·02 as the co-efficient for this rough calculation, and assuming that the air friction would be the same as if the fan were closed up all round, and merely carrying the air round and round with the vanes, it was found that the air friction would come to the enormous amount of 149 horse-power (see note at end of paper).

Two things were evident from this :—

1.—That the co-efficient used was at any rate eight times too great.

2.—That the 20 per cent. was probably lost almost entirely in air friction.

Having advanced thus far by theory, it was necessary to test the conclusions by experiment. Mr. Watson and the writer, therefore, tried experiments in order to ascertain what power was required to turn the fan round with the shutter lowered down as far as it would go, and the small aperture still left, sealed up. This was on April 13th, 1878.

The following are the results of those experiments :—

Revolutions.	Indicated Horse-power.
10	4·65
20	12·76
40	54·50

From these experiments then it could be ascertained, and, the writer believes with tolerable accuracy, how much power was spent on this air friction ; for it is a universally accepted fact, that the power spent on air friction varies as the cube of the velocity of the air.

Making use of this fact, the work done in the three experiments was able to be divided as follows :—

10 Revolutions—	Horse-power
Weight friction	3·38
Friction on slide-valve, etc., and that due to pressure on piston	·69
Air friction	·53
	4·60
Error—add	·05
	4·65

20 Revolutions—	Horse-power.
Weight friction, 3·38 × 2	6·76
Friction on slide-valve, etc., and that due to pressure on piston	1·84
Air friction, ·533 × $(\frac{20}{10})^3$	4·26
	12·86
Error—deduct	·10
	12·76

40 Revolutions—	Horse-power.
Weight friction, 3·38 × 4	13·52
Friction on slide-valve, etc., and that due to pressure on piston	6·87
Air friction, ·533 × $(\frac{40}{10})^3$	34·11
	54·50

In the above experiments what is put down as air friction, would probably not be quite all due to simple air friction, but a small portion would be spent in dashing air against the step, left where the opening of the shutter end was sealed up, and in air slipping round the tips of vanes. Supposing this to be put down as 3·11 horse-power in the third experiment, then 31·0 horse-power would be left as spent purely on air friction. This gives as the co-efficient of friction ·0019 lbs. per square foot of rubbing surface for a velocity of 1,000 feet per minute.

To confirm the results of these experiments, through the kindness of H. Richardson, Esq., the writer was allowed to try similar experiments on the 40 feet × 12 feet Guibal fan at Backworth Colliery.

With the shutter lowered down, and outlet closed up, in a similar manner as in previous experiments, the following results were obtained :—

Revolutions.	Horse-power expended.
10	3·11
30	21·30
45½	59·02

The power in the above experiments was calculated to be distributed as follows :—

10 Revolutions—	Horse-power.
Weight friction	2·02
Friction on slide-valve, etc., and that due to pressure on piston	·65
Air friction, ·437	·44
	3·11

30 Revolutions—	Horse-power.
Weight friction, 2·02 × 3	6·06
Friction on slide-valve, etc., and that due to pressure on piston	3·45
Air friction, ·437 × $(\frac{30}{10})^3$	11·79
	21·30

45½ Revolutions—	Horse-power.
Weight friction, 2·02 × 4·55	9·19
Friction on slide-valve, etc., and that due to pressure on piston	7·15
Air friction, ·437 × $\left(\frac{45\frac{1}{2}}{10}\right)^3$	41·13
	57·47
Error—add	1·55
	59·02

Put down 4·13 horse-power of the air friction in this last experiment, as due to dashing of air against step, etc., there is a remainder of

37 horse-power; which gives as the co-efficient of friction about ·0025. This is greater than that obtained from the Rockingham fan; the difference being probably due to the fact that the casing of the Rockingham fan was coated with a fine dry impalpable coal powder, whereas the casing of the other was not so coated, and the surface was moist.

The average of these two co-efficients ·0022 lbs., or ·028 feet of air column of the same density as the flowing air, being smaller than what is generally considered to be the co-efficient of friction of air against brickwork, it is probable that if there be any error in it, it is on the side of making it too small rather than too large.

Returning again to the experiments with the Rockingham fan, it was there seen that 31 horse-power was spent on air friction; it will be seen from the note at the end of the paper, that

$\frac{31}{54}$ of this, or 17·8 horse-power, is due to friction on circumference.

$\frac{23}{54}$ of this, or 13·2 horse-power, is due to friction on sides.

Now, when the fan is discharging air, the friction against the *sides* will be approximately the same, and that on two-thirds of the circumference will be the same as before, but the friction on the remaining one-third of the circumference through which the fan is discharging its air will be very small.

When the fan is discharging, then the air friction will stand as follows:—

	Horse-power.
Friction against sides	13·2
Do. do. two-thirds circumference	11·8
Do. do. remaining one-third circumference (say) ...	·6
TOTAL	25·6

This 25·6 *horse-power represents the work lost in air friction* in a 45 feet Guibal fan when discharging air, and making forty revolutions per minute.

On the same day that these experiments were tried, experiments were also tried in order to ascertain the maximum useful effect that could be obtained from the fan when working to the greatest advantage.

The shutter being almost fully open, the separation doors in one of the seams were gradually opened until the water-gauge in porch doors began to fall, in this position the doors were fixed and the experiments taken.

Before giving the results of these experiments, it would perhaps be as well to state the method adopted in making the experiments which are given in this paper.

A pendulum, with vibrations corresponding to the number of strokes at which the engine was desired to go, was fixed to swing with small vibrations near to one end of the piston rod. When the beats of this pendulum and the strokes of the piston rod were found to be exactly synchronous the indicator diagram was taken and the water-gauge simultaneously observed. (In timing with a watch there is a liability to error because the engine may be going slower than the required speed at the beginning of the timing and faster at the end, and yet make the requisite number of strokes in the minute during which it is being timed.)

The number of strokes that the engine made during the time that the measurement of the air took place were counted, and the volume of air obtained reduced to the quantity it would be at the n° = number of strokes at which the indicator diagram was taken; the rule that the quantity of air varies as the speed of the engine being assumed to be correct for the small difference in the two speeds.

The drift was divided into sections of equal area, and time was called every half minute, the anemometer was moved from section to section each half minute so that there was no stoppage during the measurement, and the measuring occupied as little time as possible.

The anemometers used were of the type commonly called Casella, and were corrected by testing.

The following are the results of the experiments with the Rockingham fan :—

Guibal Fan, 45 feet diameter and 12 feet wide. Diameter of Inlet, 15 feet. Effective area of Piston, 1,000 square inches. Area of drift, 198 square feet.								
Revolutions of fan.	Average pressure in cylinder.	Indicated horse-power of engine.	Average speed of fan during measuring of air.	Quantity as measured by anemometer.	Quantity when reduced to speed in first column.	Water-gauge in drift.	Horse-power in air.	Per cent. of useful effect.
				Cubic feet.	Cubic feet.			
20	6·10	22·18	20½	82,332	80,982	·65	8·31	37·4
30	9·88	53·89	30½	119,773	117,810	1·44	26·78	49·7
40	15·79	114·84	39½	159,889	163,152	2·56	65·94	57·4

The writer thinks that these experiments show the maximum useful effect that can be obtained at those speeds from that fan when working under the most favourable conditions. They give the highest useful effect obtained out of more than 30 experiments, tried by different persons at various times, including experiments by Mr. D. P. Morison.

It has been shown that at 40 revolutions the air friction was 25·6 horse-power; therefore, taking the last experiment, the air friction absorbed 22 per cent. of the whole power employed. Thus, it was evident that if a fan could be constructed which, while retaining those features that had made the Guibal superior to other fans, did not waste so much of its energy in air friction, it would give a higher percentage of useful effect than the Guibal. Now, the only feasible way of reducing this friction was by reducing the size of the fan; and in order to reduce the size of the fan, it was necessary that it should discharge all round the circumference. If, when the whole circumference discharged into one outlet tube there was a diminution in the vacuum produced; then, to cause the same quantity of air to circulate, the fan would have to be run at a greater speed; but as the work spent on air friction increases as the cube of the speed, the saving through reduction in the size of the fan would soon be lost on account of the extra speed at which the fan would have to be run to get the same vacuum as the large fan. With three outlets, however, as good a vacuum was got as by a Guibal; five outlets were tried, but the increase in water-gauge over three outlets, was hardly appreciable.

As the diameter of the fan was reduced, it became necessary to admit the air through both sides of the fan casing, and a fan so constructed, with three *evasé* outlets, was found able to do the same work as a Guibal of double the diameter; therefore, if the Guibal wastes 22 per cent. of the whole power employed in air friction, a fan of the improved type will only waste $5\frac{1}{2}$ per cent., showing a saving of $16\frac{1}{2}$ per cent. of the power; for the work spent on air friction varies as the square of the radius of the fan, if the width and radius of the fan are reduced in the same ratio.

For let ρ be the radius of the inlet opening to the fan, and R the radius to tips of vanes in any fan, and let ρ bear always the same ratio to R; then, if the distance between ρ and R be divided into any constant n° = number of rings, in every case the area of each ring will vary as R^2; consequently, the pressure required to overcome the friction of sides will vary as R^2. So if the width of the periphery bears always the same proportion to R, the pressure required to overcome the friction of the periphery will vary as R^2.

The following table compares the working of the two types of fans in practice, at about the same periphery speed, and shows the distribution of the work done.

Work spent on	Guibal fan, 45 feet by 12 feet, 30 revolutions.		Bowlker and Watson's fan, 8 feet 6 inches by 3 feet, 150 revolutions.	
	Horse-power.	Per cent.	Horse-power.	Per cent.
Engine and fan journal friction ...	16·23	30·3	1·75	26·8
Ventilation (useful effect) ...	26·78	49·7	4·19	64·0
Air friction and other loss ...	10·78	20·0	·60	9·2
	53·79	100·0	6·54	100·0

The experiment on the Guibal is the same as was brought forward earlier in the paper. That on the other fan is one of a series of experiments tried in January of this year, on one of Bowlker and Watson's fans, erected in June, 1881, at the Byron Colliery, near Haltwhistle.

The experiments were tried under the ordinary conditions of ventilation, and are given below :—

Bowlker and Watson's fan, 8 feet 6 inches diameter, driven by one of Marshall's portable engines, with two 8¼ inch cylinders. Effective piston area 56 × 2 square inches. Stroke 1 foot. Barometer 28·60. Thermometer in drift 58.

Revolutions of engine per minute.	Revolutions of fan.	Quantity of air as measured by anemometer.	Strokes of engine during time of air measurement 4¼ minutes.	Quantity reduced to speed in first column.	Average pressure in cylinders.	Indicated horse-power of engine.	Water gauge on porch doors.	Horse-power in air.	Per cent. of useful effect.
		Cubic feet.		Cubic feet.	Lbs. ℔ sq in		Inches.		
60	150	19,883	272	19,737	16·06	6·54	1·35	4·19	64·0
80	200	25,252	365	24,906	26·39	14·33	2·30	9·03	62·9
90	225	30,798	405	30,798	35·71	23·81	2·85	13·83	63·4

The following were with the engine alone, the belt being taken off:—

Revolutions of Engine per Minute.	Average Pressure in Cylinders. Lbs. per Square Inch.	Indicated Horse-power of Engine.
20	·89	·12
40	1·22	·33
60	1·65	·67
90	2·08	1·27

There are other minor features in this fan which help to increase its useful effect. The vanes are curved in such a manner as to lose as little power as possible through concussion of air. There is also a curved cast iron diaphragm on the fan shaft. This it may be remarked is not a new idea, though it is wanting in most types of fans. It has been adopted in this one in order to save as much of the kinetic energy of the entering air as possible, whilst at the same time it materially adds to the rigidity of the structure.

The writer would ask in conclusion, whether the experiments that have been brought forward, and the facts that have been adduced do not go to prove that a fan of the type herein named must, as was claimed at the beginning of the paper, give from 10 to 15 per cent. more useful effect than the Guibal?

The writer begs to thank Professor Aldis for his kindness in examining into the correctness of the writer's investigation as to formula for air friction; and also Mr. Henry Richardson for affording facilities for trying experiments with his fan; and Mr. Croudace, Mr. T. Croudace, and others who have assisted in trying experiments. He must also acknowledge the help derived from a perusal of the valuable papers communicated to the Institute by Mr. W. Cochrane.

Note 1.—FRICTION OF AIR IN FANS.

Let O be the axis of the fan; let OB be the radius to the inner ends of vanes, and OC the radius to the outer ends, so that the annulus of air between B and C is moved round by the fan vanes and rubs against the sides of the fan casing, and also against the circumference; and assume that there is no churning action, but that the path of each particle of air is a circle, and the particle of air moves along this circle with uniform velocity.

$$\text{Let OB} = \rho \text{ feet, OC} = \text{R feet.}$$

Let the annulus be divided into an infinite number of concentric rings. Then the area of any ring whose radius is r will be $2\,\pi\,r\,dr$. Let k represent the co-efficient of friction (in pounds), or the pressure required to overcome the friction of the air on one square foot of rubbing surface for a velocity in the air of 1,000 feet per minute.

Let ω be the angular velocity of the fan per minute; then the velocity of ring of radius $r = \omega\,r$ feet per minute; then *pressure* required to overcome friction on any ring

$$= 2\,\pi\,r\,dr \times k \times \left(\frac{\omega\,r}{1{,}000}\right)^2 \text{ lbs.}$$

The *work* done per minute in overcoming friction on *each* ring

$$= \left\{ 2\,\pi\,r\,dr \times k \times \left(\frac{\omega\,r}{1{,}000}\right)^2 \right\} \omega\,r \text{ ft. lbs.}$$

$$= \frac{2\,\pi\,r\,dr \times k \times \omega^3\,r^3}{1{,}000{,}000} \text{ ft. lbs.}$$

Therefore, total work done on one *side* of fan

$$= \frac{2\,\pi\,\omega^3\,k}{1{,}000{,}000} \int_{\rho}^{R} r^4\,dr = \frac{2\,\pi\,\omega^3 k}{5 \times 1{,}000{,}000} (R^5 - \rho^5) \text{ ft. lbs.}$$

Let B be the breadth of the fan at circumference, then work done on *circumference*

$$= 2\,\pi\,R \times B \times k \times \left(\frac{\omega\,R}{1{,}000}\right)^2 \times \omega\,R \text{ ft. lbs.}$$

$$= \frac{2\,\pi\,BR^4\,\omega^3 k}{1{,}000{,}000} \text{ ft. lbs.}$$

Using these formulæ we find in the case of a Guibal fan, in which

$R = 22{\cdot}5$ ft., and $\rho = 7{\cdot}5$ ft., $B = 12$ ft.

Let $\omega = 80\,\pi$

Work spent per minute on friction of *circumference*—

$$W = \frac{24\,\pi\,k\,R^4\,\omega^3}{1{,}000{,}000} \text{ ft. lbs.}$$

Work on each *side*—

$$= \frac{2\,\pi\,\omega^3 k}{5{,}000{,}000} \left\{ (22{\cdot}5)^5 - (7{\cdot}5)^5 \right\} \text{ ft. lbs.}$$

Work on both *sides*—

$$W' = \frac{4\,\pi\,\omega^3 k}{5{,}000{,}000} \left\{ 5{,}766{,}503 - 23{,}730 \right\} \text{ ft. lbs.}$$

$$= \frac{4\,\pi\,\omega^3 k}{5{,}000{,}000} \left(5{,}742{,}773 \right) \text{ ft. lbs.}$$

Total work spent on air friction—

$$W + W' = \left\{ \frac{120 \times 256{,}289 + 4 \times 5{,}742{,}773}{5{,}000{,}000} \right\} \left\{ 80^3 \pi^4 k \right\} \text{ ft. lbs.}$$

$$= \left\{ \frac{53{\cdot}726}{5} \right\} \left\{ 512000 \times 97{\cdot}41 \right\} k \text{ ft. lbs.}$$

$$= 535905245\,k \text{ ft. lbs.}$$

Now, from experiment it was found that this was equal to 31 h.p.

$$\therefore\ 31 \times 33000 = 535905245\,k$$

$$k = \frac{1023000}{535905245}$$

$$= {\cdot}0019$$

NOTE 2.—THE MODE OF CALCULATING THE FRICTION IN THE EXPERIMENTS.—FRICTION IN BYRON FAN ENGINE.

The area of piston being 56 square inches, the friction per lb., per stroke, may be estimated as follows—

SLIDE BLOCKS—

Pressure on slide $= 56 \times \frac{1}{10} = 5{\cdot}6$ lbs.
Take co-efficient of friction (which call μ) $= {\cdot}1$
Force required $= 5{\cdot}6 \times {\cdot}1 = {\cdot}56$ lbs.
Work per stroke $= {\cdot}56 \times 2$ ft. $= 1{\cdot}12$ ft. lbs.

CRANK PIN—10 in. round.

Pressure on pin, say 60 lbs.
Take $\mu = {\cdot}04$
Force required $= 60 \times {\cdot}04 = 2{\cdot}4$ lbs.
Work per stroke $= 2{\cdot}4 \times \frac{10}{12}$ ft. $= 2$ ft. lbs.

CRANK SHAFT JOURNALS—10 in. round.

Pressure 56 lbs.
Take $\mu = {\cdot}04$
Force required $= 56 \times {\cdot}04 \quad = 2{\cdot}24$ lbs.
moved through $\frac{10}{12}$ of a foot $= \quad 1{\cdot}8$ ft. lbs.

CROSSHEAD— say ·1 ft. lbs.

Total $1{\cdot}1 + 2 + 1{\cdot}8 + {\cdot}1 = 5$ ft. lbs. for each cylinder
or 10 ft. lbs. for the two cylinders.

Thus the friction due to pressure on *piston* is 10 ft. lbs. per stroke, per lb. pressure in cylinder.

SLIDE VALVE—Area 34 sq. in., stroke $2\frac{1}{2}$ in.

Take $\mu = {\cdot}2$
Force required $= 34 \times {\cdot}2 = 6{\cdot}8$ lbs.
Work per stroke $= 6{\cdot}8 \times \frac{5}{12}$ ft. $= 2{\cdot}8$ ft. lbs.

ECCENTRIC—$2\frac{1}{4}$ ft. round.

Take $\mu = {\cdot}05$
Pressure $= 6{\cdot}8$ lbs.
Force required $= 6{\cdot}8 \times {\cdot}05 = {\cdot}34$ lbs.
moved through $2\frac{1}{4}$ ft. $= {\cdot}76$ ft. lbs.
Total for slide valve and eccentric 3·56 ft. lbs.
Total for the two do. 7·12 ft. lbs.

and thus 7·12 lbs. is the friction per stroke, per lb. pressure on the slide valve.

The above calculations are of course only approximate, as it is impossible to ascertain what the exact co-efficient of friction is in any engine. The weight and momentum of the moving parts also interfere more or less with the pressures assumed.

From the above data the amount of friction in engine is thus found.

60 REVOLUTIONS—ENGINE ALONE.

	Ft. lbs.	
Average pressure in cylinder 1·65 lbs. Ft. lbs. of work		22,176
Friction as pressure on piston 10 × 1·65 × 60 =	990	
Friction as pressure on valve 7·1 × 3·3 × 60 =	1,405	
		2,395
Remainder—called "weight friction" (and considered to be due simply to the weight and momentum of moving parts.)		19,781

THE FRICTION AT 60 REVOLUTIONS WITH FAN GOING THEN IS—

	Ft. lbs.
Weight friction	19,781
As pressure on piston 10 × 16·06 × 60 ...	9,636
As pressure on valve 7·1 × 21·0 × 60 ...	8,946
Due to belt friction and tension	1,400
Fan journals (take μ = ·03, weight = 4000 lbs.) (ft. lbs. per rev. = 4000 × ·03 = 120) 120 × 150	18,000
	57,763

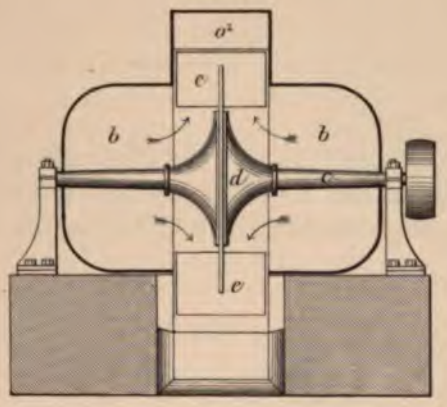
or 1·75 H.P.

Mr. A. L. STEAVENSON read the following "Remarks on the Machinery at the Skelton Park and Lumpsey Mines:"—

To illustrate Mr. T. J. Bowlker's paper "Description of a New Ventilating Fan."

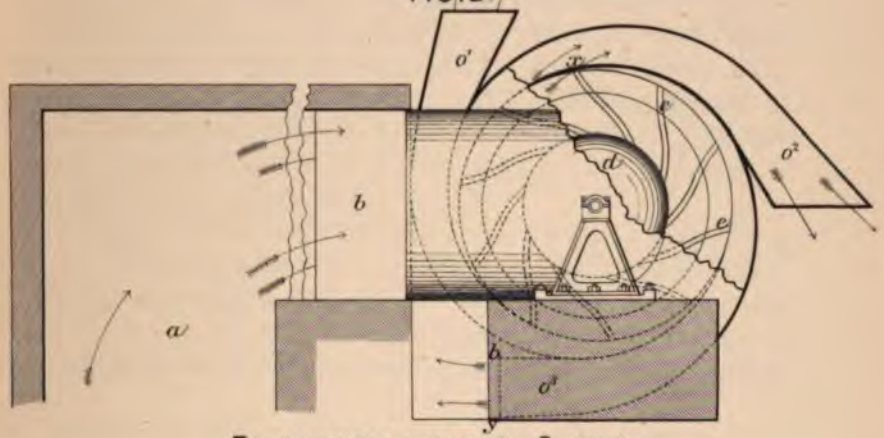
BOWLKER & WATSON'S VENTILATOR.

FIG. 1.



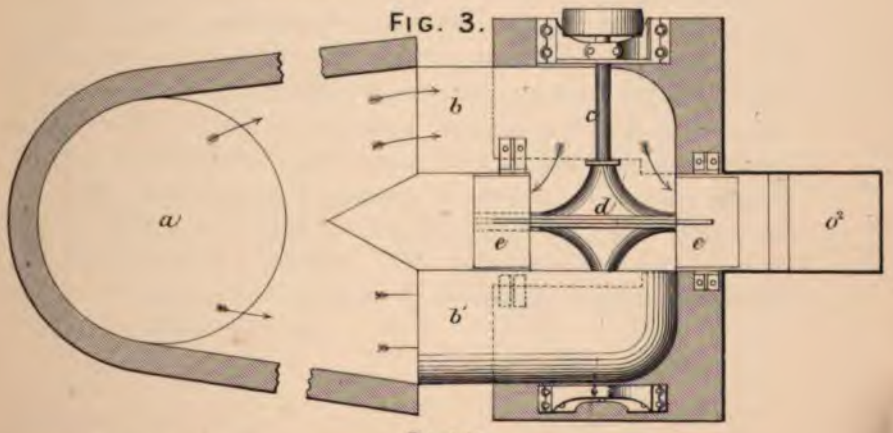
VERTICAL TRANSVERSE SECTION.

FIG. 2.



ELEVATION AND PART SECTION.

FIG. 3.



PLAN.

REMARKS ON THE POINTS OF INTEREST AT THE SKELTON PARK AND LUMPSEY MINES, ON THE OCCASION OF THE VISIT OF THE INSTITUTE, SEPTEMBER 16TH, 1881.

By A. L. STEAVENSON.

At the first or Skelton Park Mine especially noticeable is the system of mechanical drilling of the shot holes, and the haulage by endless rope on the underground main roads—in both cases by compressed air.

The air compressor, which is placed on the surface, has air and steam cylinders, both of 22 inches diameter and 6 feet stroke. The air, usually compressed to 45 or 50 lbs. per square inch, is taken down the shaft 60 fathoms, and 450 yards in-bye, in 9-inch pipes and distributed, by smaller ones, to three districts, in each of which there is a drilling machine to every eight or nine working places.

The total cubic capacity of the receiver and pipes is at present 2,041 feet, and the displacement of the air cylinder 31·2 cubic feet per revolution.

As the use of compressed air has never hitherto gone much beyond the mere description of machinery in the Transactions, it may be well to look into the practical and theoretical considerations which are incident to its use.

Notwithstanding that the engineers on the Continent have for many years recognised the great loss of useful effect which follows compression without adequate cooling appliances in the shape of jets of water spray, such as are here applied in the cylinder, few English compressors will be found having anything better than the ordinary water bath; so serious is this that at 75 lbs. effective pressure the excess of work to be developed amounts to 25 per cent., and even at the more usual pressure of 45 lbs. per square inch it equals very nearly 20 per cent. To remedy this, all that is required is to inject into the cylinder about 1 gallon of water per 100 cubic feet of air compressed. The temperature due to this pressure is about 350 degrees Fahrenheit, but by the spray it is maintained steadily at not more than 80 degrees.

Still, when these matters are carefully attended to, compressed air, if used without expansion, leads to a great loss of power. The work given out soon reaches a limit which cannot be exceeded, whatever may be the pressure of the air or the energy expended.

The great error made in using high pressure where it can possibly be avoided, was clearly shown some time ago by Mons. Trasenter, of Liége. He puts it this way :—

"The maximum of work given out (increasing the compression indefinitely and without taking into consideration the elevation of temperature due to this compression) cannot exceed the energy given out by the volume of air acted on by the piston of the blowing cylinder, working with an effective pressure of one atmosphere. This law is easily demonstrated—

Let p = the pressure of the atmosphere—10,333 kilograms per square mètre.
P = do. do. compressed air.
V and v = their corresponding volumes.

Then $P = n\,p$, or $V = n\,v$.

The work which this air is able to give out theoretically is

$$(P - p)\,v = P\,v - p\,v$$

and, as $P\,v = p\,V$, it follows that

$$P\,v - p\,v = p\,(V - v) = p\,V\,(1 - \tfrac{1}{n}).$$

Therefore, a cubic mètre of air compressed to no matter what pressure can only give out a power equal to

$$p \times 1 \text{ or } 10{,}333 \text{ kilogrammètres}$$

when $\frac{1}{n} = O$, or when n is infinite, whilst the same cube compressed only to two atmospheres gives out

$$T = 10{,}333\,(1 = \tfrac{1}{2}) = 10{,}333 \times \tfrac{1}{2} \text{ kilogrammètres.}$$

The quantity of power which a cubic metre of air compressed to a million atmospheres is capable of yielding, without taking the rise of temperature into consideration, can never become double that which the same quantity of air compressed to two atmospheres is capable of yielding.

Air compressed to four atmospheres will give out a power proportional to $(1 - \frac{1}{4})$ or $\frac{3}{4}$, whereas to obtain a power equal to 1, a compression infinitely great is necessary.

In another form the work given out may be expressed by the following logarithmic formula—

$$T = p\,V \log.\, nap,\, n -$$

that is to say that it increases as the powers of n.

The following formula then expresses the ratio of the work done to the power expended—

$$E - \frac{p\,V\,(1 - \frac{1}{n})}{p\,V\,2{\cdot}303 \log.\, n} = \frac{1 - \frac{1}{n}}{2{\cdot}303 \log.\, n}$$

by writing n^x instead of n we obtain

$$E = \frac{1 - \frac{1}{n^x}}{2{\cdot}303\, x \log.\, n}$$

The power expended increases as the powers of n while the work done can never attain unity, but may be represented by an asymtotic curve, or hyperbola.

By giving to x values ranging from 1 to 6, and to n the value 2, it will be found that—

$E = 0{\cdot}72$	for 2 atmospheres	when	$x = 1$
0·54	„ 4	„	„	$x = 2$
0·42	„ 8	„	„	$x = 3$
0·34	„ 16	„	„	$x = 4$
0·28	„ 32	„	„	$x = 5$
0·23	„ 64	„	„	$x = 6$

As a matter of engineering interest it may be mentioned that at present, in order to conduct the air from the compressor down the shaft to the hauling engine and drills in three different districts, there are—

1,101	yards of	9 inch pipes.
640	„	6 „
700	„	2 „
670	„	1¼ „

And to test the amount of leakage, when the pressure is raised to 55 lbs., it falls back

1 atmosphere in	... ...	50 minutes.
2 „ „	... ...	2 hours 6 „
3 „ „	... ...	3 „ 35 „
3¾ or total pressure	... ...	6 „

This seems a great loss, but with such a large number of small pipes and having above 1,000 joints, such a drawback to the system seems inevitable, and can be only met by frequent tests and strict attention to details.

MECHANICAL DRILLING.

The ordinary mode in Cleveland is by hand drilling, holes varying from 3 to 5 feet in depth, triangular in form, and 1½ inches on each side. A good man can drill 6 feet per hour, but not continuously throughout his shift.

From statistics the writer got when preparing some evidence, he found that 29 hand-drilled holes were equal to 94 feet in length, that they were charged with 684 ounces of powder, which occupied 33 feet, the stemming filling up the remainder—roughly, the powder equals ⅓ of the length of the hole, which is equal to 20¾ ounces of powder per foot or 7·27 ounces per foot drilled.

Then, as other statistics show, each ton of ironstone requires 6 ounces of powder, $\frac{684}{6} = 114$ tons of stone; 94 feet of hole = 114 tons or 1·21 tons per foot drilled.

A miner averages 5½ tons of stone per day, which gives 4·55 feet drilled per man per day; this latter amount of 6 ounces per ton of iron-

stone is the average of the district, but in this mine it is nearly 8 ounces, making 6 feet of drilling per day per man, the remainder of his work consisting in breaking up the stone and filling it into wagons.

With a view of ascertaining whether any saving could be effected in the amount of labour required by such a large amount of drilling, Messrs. Bell Brothers, after having experimented upon a variety of other drills, eventually adopted those now in use, in the year 1876, which are the invention and patent of Mr. W. Walker, of Saltburn-by-the-Sea. They were designed solely for the Cleveland ironstone, and were the first kind of mechanical drills practically and successfully proved to achieve the object sought. They were first used at Staughon Mines, where Mr. Walker worked them himself: Messrs. Bell Brothers commencing to use them afterwards. Messrs. Pease, and Messrs. Bolckow, Vaughan, and Co. afterwards introduced, and have since continued the use of, the percussive machines.

Mr. Walker has recently made some modification in his machines, and has some of the altered designs working at the Boosbeck Mines, where he is getting over 80 tons per shift from one machine. The stone is very hard at this place, and requires as much powder as at the Park, or neighbouring mines.

In Plate XIII., which shows the altered form of the machine, *x x* is a strong bogy, which has a hollow upright *a* attached, of a height suitable to the seam; on each side of this upright is a slot *y y*. Closely fitting this upright are two circular tables *z z*, provided with feathers fitting in the slots or grooves *y y;* these tables are attached to two bars *w*, Fig. 2, provided with two bosses *t t*, in which work the two screws *v v*, so that when the screws are caused to turn round they move the tables *z z* up or down as may be required; the motion is given to the screws by means of bevelled gearing and the handle *c*, which can be applied to either screw by affixing it either to the spindle *r* or *s*.

Above the tables *z z* are two wrought iron frames *b b*, which also embrace the upright *a*, so that they can be moved round in any direction, and are secured to *z z* by means of the bolts and hooks *m m*; to these frames arms *q q* are attached by the bolts *o o*, and to these again the two drilling machines, by means of the screws *p p* and the clamps *h h*. By these arrangements it will be seen that the drilling machines can be moved up or down, or in any other direction that may be required.

The drilling machine is a very simple and pretty contrivance. It consists of a casting in which are the two air cylinders 5½ inches diameter and 2½ inches stroke at *a b*, which however are not shown, being hidden by

the frame; the air is carried to them by the cock *m*. These cylinders work a crank axle *n*, which is geared by means of a pinion into a wheel *f* which drives a sleeve *d*, provided with feathers working in grooves cut in the screwed spindle *i*, in the ratio of 1·75 to 1. The axle is also geared on the other side by means of a pinion and wheel *e* in a ratio of 2·4 to 1; this wheel *e* is attached to a nut which works over the screw *i*, which has four threads to one inch; this nut is kept in its place by the bearing *c*, and either remains stationary or not as the clutch *k* may happen to be disconnected or in gear. When disconnected the nut is stationary, and the drill advances 1 foot for every $4 \times 12 \times 1{\cdot}75 = 84$ revolutions of the engine. When, however, the wheel *e* is in gear, the nut advances in the same direction, and checks the advance of the drill at the rate of $\frac{84}{2{\cdot}4} = 35 \times \frac{1}{4} = 8{\cdot}75$ inches; the difference, 3·25 inches, been the actual advance. When the drill enters the rock, this clutch is put in gear, and is taken out when the drill is withdrawn. The drill *g* is fixed to the driving screw *i* by means of a universal joint, so that it may alter its direction with any difference that may arise in the nature of the rock to impede its progress, *a′ b′* are the exhaust holes, *l* is a wheel which serves as a starting gear, and *k′* is a counterbalance weight.

A machine of this description is now being made for Messrs. Bell Brothers; whilst others are also to be applied by Messrs. Palmer & Co., at the Port Mulgrave and Grinkle Mines.

With a pressure of 40 lbs., holes are drilled at the rate of 2 feet per minute 2 inches in diameter, which allow the powder to get well to the bottom of the hole and they act as efficiently as the triangular holes made by the miners.

Each drill is in charge of one skilled miner who has with him an assistant, and in a shift of 8 hours they put in about 20 holes, averaging from 4 to 5 feet in depth. After they leave the place they are followed by a skilled miner who charges and fires the shots; labourers then break up and fill the ironstone, so that two skilled men do the work usually requiring nine.

Seven or eight working places are set apart for each machine; at the present time three are at work, and as they each work two shifts per day, the total production somewhat exceeds 300 tons.

The tons per hole were found over a long period to average 2·98 and the cost for powder 2·03d. The drill consists of a twisted augur-shaped tool, made from an oval bar of steel specially manufactured for the purpose, the result being such that it is intended to increase the use of them.

At the mines of the other owners previously mentioned, they have adopted drills with a percussion action, such as the Burleigh and Ingersoll, but the nature of the ironstone is such that unless water at a high pressure is injected into the hole it quickly forms a pasty mass which chokes it and stops the operation, so that they have the double trouble and expense of conveying water as well as air throughout the workings.

HAULAGE BY ENDLESS ROPE.

The system of endless rope working has been described in the well-known report on "Underground Haulage" (Volume XVII.)

Its great value consists in the slow continuous movement, in the almost total absence of friction, in the movement of the rope, and in the advantages obtained from any part of the road having a gradient in favour of the load instead of great lengths of the rope being dragged at high speeds varying from 10 to 20 miles per hour over rollers, the whole length and weight is carried by the wagons. Its advantage had been well tested by the writer at Pagebank Colliery, where the rope is carried on the top of the tubs; but in this district the wagons are so heavily loaded that the stone projects 15 inches above them, and it was therefore necessary to design an attachment underneath. This has been very successfully done by means of an arrangement shown in Plates XIV. and XV.

The cylinder of the engine which drives the rope, is only 12 inches diameter by 18 inches stroke, and is connected by bevel gearing to an upright shaft, which carries a 6-foot clip sheave, and this, with an indicated power of 7 horses, is sufficient on a level road to bring out 750 tons per day a distance of 800 yards. Each wagon carries about 35 cwts., and its resistance is about 40 pounds per ton.

The writer acknowledges that compressed air does not afford a high, useful effect; but, in mines, steam engines and boilers are the indirect cause of much greater expense, often coupled with danger.

Plate XIV. shows the self-acting attaching apparatus, which consists of a bent lever *a*, working between a split rail *x;* this lever is keyed on a socket sliding on the shaft *b*, which it turns by means of feathers, on which are also keyed two other levers *c* and *d;* the lever *c* has a roller which lifts the rope when *a* is depressed by the tub running over it when the lever *d* with its roller *e* rubbing against the bevelled upright *l* draws the shaft *b* and the lever *c* with the rope towards the hook *k* into which it falls after the wagon has passed.

When it is decided not to attach the tubs to the ropes the lever *a* can be withdrawn from between the split rail by the handle *g*. In order that the hook *k* may be always in the position to receive the rope a piece of

angle iron *h*, working on a pivot *y* and kept in position by a weight and pulley *o w*, is placed in a slanting position between the rails; this catches the hook in whatever position it may be in when the tub comes up and turns it round till it is in the position shown at Fig. 3.

The detaching apparatus, Plate XV., is much more simple, and consists of the lever *a* working between split rails and actuated by the passing tub. This turns the shaft *d*, raises the lever *b*, and lifts the rope out of the hook *k*. During the time a slight divergence made in the line of rail causes the hook to move aside from the rope which then drops when released by the lever *b*.

LUMPSEY SHAFTS.

The number of shafts sunk in the northern districts has been of late years so very small that it was chiefly to give the younger members of this Institution an opportunity of visiting sinking pits that the invitation was offered.

The strata of the district is of course much milder in its character than in the coal-field. Mr. John Marley, in his Paper, Vol. V., page 165, on the "Cleveland Ironstone," gives all the necessary geological description of it; but it is in the porous soft nature of the strata that the great difficulty in sinking pits consists, as so little suitable rock for making crib beds is met with.

The sinking of two 15 feet pits commenced on the 26th April, 1880, and the ironstone, at a depth of 94 fathoms, was reached 3rd November, 1881.

During this time feeders of water, amounting to 1,700 gallons per minute, were passed through, and nearly 60 fathoms of tubbing put in.

As it was always intended to tub off the water, a temporary pumping engine only was erected, consisting of two 24 inch cylinders by 4 feet stroke, geared 3 to 1, with 45 pounds steam pressure.

The pumps, one 20 inch set and one 18 inch set, both worked in the bottom.

1.—At 6 fathoms	3 feet	...	The walling and ring crib ...		Figs. 1 and 2, Plate XVI.
2.— „ 16	„ 2	„ ...	Single crib, 20″ × 6″, laid but failed to hold the water, 400 gallons per minute	„ 3	„ 4, „
3.— „ 27	„ 3	„ ...	Single crib, 20″ × 6″, held the water.	„ 3	„ 4, „
4.— „ 34	„ 3	„ ...	„ „ „ „ proved bad...	„ 3	„ 4, „
5.— „ 37	„ 0	„ ...	4th double crib laid, this stopped 200 gallons	„ 5	„
6.— „ 51	„ 5	„ ...	5th double crib laid, 22″ × 6″ and 20″ × 6″	„ 5	„
7.— „ 55	„ 0	„ ...	6th double crib laid, 22″ × 6″ and 22″ × 6″	5 „ 2	„

Below this the alum shale or upper lias and the jet rock, being of a soft impervious nature, contained no water, but in the lower part much inflammable gas.

The cribbing is shown in detail in Plate XVI. The ring crib, Fig. 1, is about 4 feet $7\frac{1}{8}$ inches across the inner arc, and has a ring or gutter *a* to collect any water that may run down the walls of the shaft; it is $1\frac{1}{2}$ inches thick all over. Figs. 3 and 4 show the three single cribs, Fig. 4 being a section through A B, Fig. 3; these cribs are also $1\frac{1}{2}$ inches thick. The three bottom double cribs are shown in Fig. 5, the top one being 22 inches wide, and the bottom one 20 inches, the plan being the same for all, as shown in Fig. 3. Both the single and the double cribs have escape valves *c*, Figs. 3 and 5, to release the air as it escapes from the back of the tubbing; where the double cribbing is used, the top crib has simply a hole cast in it to allow the projecting part of the bottom to pass through. The tubbing is shown in Plate XVII., Figs. 1 and 2. The tubbing of the first twenty fathoms was made $\frac{3}{4}$ inch thick; the second twenty, $\frac{7}{8}$ inch thick, and the last twenty, 1 inch thick. Every segment of tubbing has a hole *x* in its centre, fitted with a wooden plug, which can be bored out when it is desired to tap the tubbing.

When a suitable place is found to lay the various cribs, the diameter of the shaft is widened out and the bed carefully levelled all round; the segments are then placed in position on the stone; between each segment a piece of $\frac{1}{2}$ inch deal sheeting is placed, and behind, pieces of deal are carefully packed. As soon as the whole is laid it is wedged tight by driving in wooden wedges both behind and in the joint. The tubbing is wedged in, in a similar manner. Fig. 2, Plate XX., shows how the tubbing is finished off at the bottom where it rests upon the last double crib. The last row but one of tubbing *a* is widened out at its bottom flange, the last row *b* has both top and bottom flanges as wide as the bottom flange of *a*, and in suitable places has pockets cast in it to carry the ends of the wrought girders *a*, Fig. 1, which support the cistern and the whole weight of the pumps which are placed within them. This row of tubbing again rests on the double cribs *c d*.

Dynamite, on account of its efficiency under water, was almost entirely used; in the pumping shaft 2,029 shots were fired and a great number of shifts were worked by sinkers, including all work at the tubbing and pumps.

The mine, when fully opened, is intended to produce 1,500 tons in 8 hours.

The winding engines, built by John Fowler and Co., will consist of a pair of 42 inch cylinders with 6 feet stroke, with a conical drum increasing from 17 feet to 21 feet.

Number of coils on the spiral, 10.

	Tons.	Cwts.
Weight of cage and chains	3	0
Two empty tubs	1	4
Two tubs of ironstone	3	8
Rope from pullies	1	0
Gross load	8	12

Time in drawing, 30 secs.; time in changing, 25 secs. Distance of drum to centre of pit shaft, 115 feet;—and the whole placed upon a concrete pillar, composed of 12 parts of freestone to 1 of cement.

It will be observed that one or two of the cribs failed to hold the water. This was not so much from the character of the stone as from the shaft having been sunk on a fault.

Plate XVIII. shows the general arrangement of the sinking machinery at the surface; *a* is the main jack engine-house used for raising the men, stone, rubbish, &c.; *b* is the pumping engine-house. The engine has two cylinders 24 inches diameter by 4 feet stroke, it is geared 3 to 1, and is worked with steam at 45 lbs. pressure. *c* is the crab engine-house—this engine has two 14 inch cylinders with 2 feet stroke, and they work the crab by means of a screw and worm wheel.

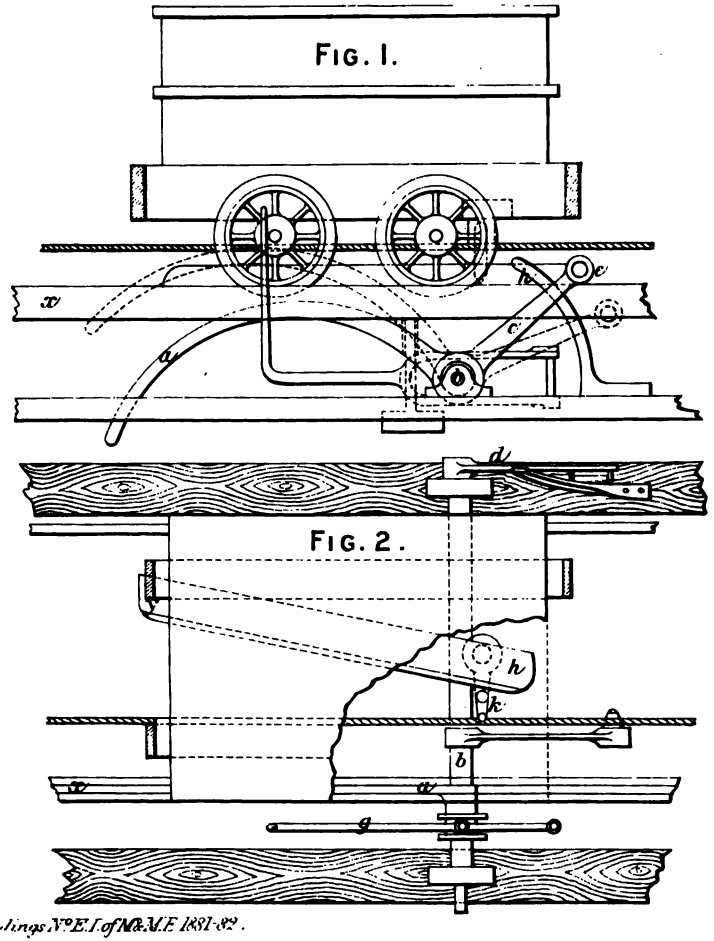
Plate XIX. shows the mode of hanging the sets by means of ground blocks, and tackle *a b*, and Plate XX. shows the mode in which the pumps and cisterns are supported by the tubbing.

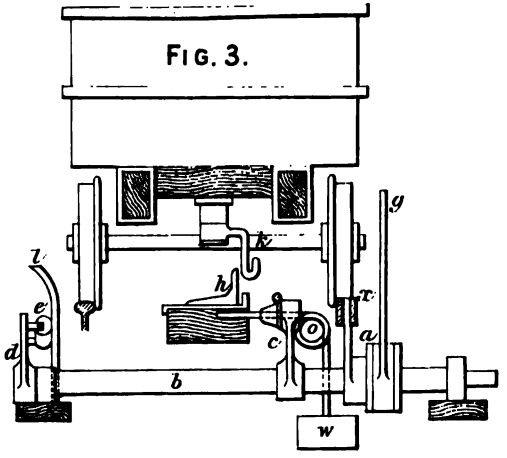
The strata passed through is given in the following table :—

LUMPSEY STRATA ACCOUNT.

	Fs.	Ft.	In.		Fs.	Ft.	In.
Soil		4	0				
Gravel	1	5	0	...	2	3	0
Soft yellow friable freestone	1	0	0	...	3	3	0
Yellow freestone	3	0	1	...	6	3	1
Soft blue metal	3	5	0	...	10	2	1
Grey freestone, with a little water ...		5	6	...	11	1	7
Soft blue metal		5	0	...	12	0	7
Small band of coal			6	...	12	1	1
Soft blue metal, with a little water ...	3	1	3	...	15	2	4
Grey freestone, water on the increase ...	3	3	5	...	18	5	9
Dark brown freestone, with water ...		5	8	...	19	5	5
Soft grey shale	1	1	9	...	21	1	2
Freestone, with a little water	3	2	9	...	24	3	11
Soft metal	2	0	6	...	26	4	5
Grey post		3	0	...	27	1	5
Grey shale		1	0	...	27	2	5
Grey shale		4	0	...	28	0	5

Proceedings Vol. I. of M.&M.E. 1881-82.



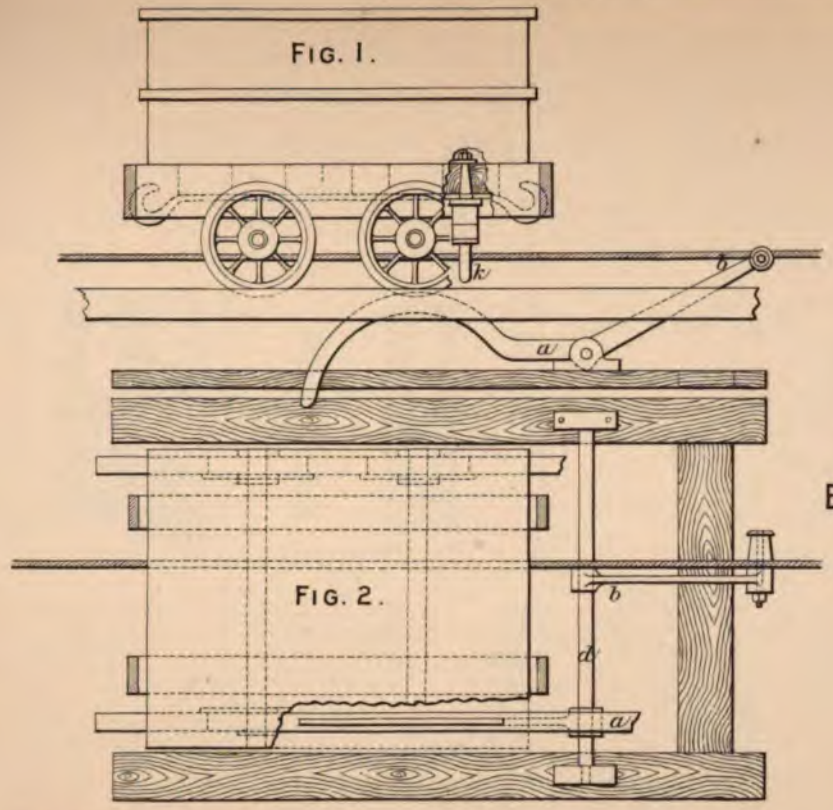


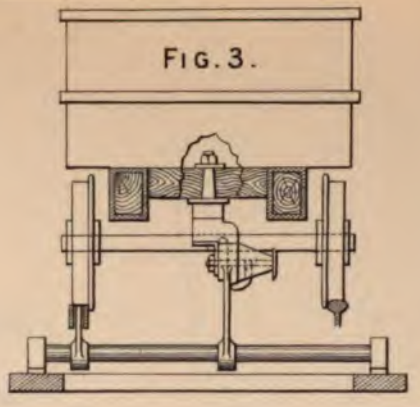
ENDLESS ROPE HAULAGE.
ATTACHING ARRANGEMENT.

Scale ½ inch = 1 foot.

Andrew Lee, Newcastle

To illustrate Mr A. L. Stevenson's paper "On the Machinery at the Skelton Park and Lumpsey Mines."





Endless Rope Haulage _ Detaching Hook.

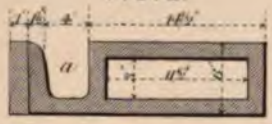
Scale ½ inch = 1 foot.

Proceedings No. E.I. of M. & M.E. 1881-82.

To illustrate Mr. A. L. Stevenson's paper "on the Machinery at the Skelton Park and Lumpsey Mines."

FIG. 1.

FIG. 2.



SECTION THRO' A.B.

SINGLE CRIB.

FIG. 3.

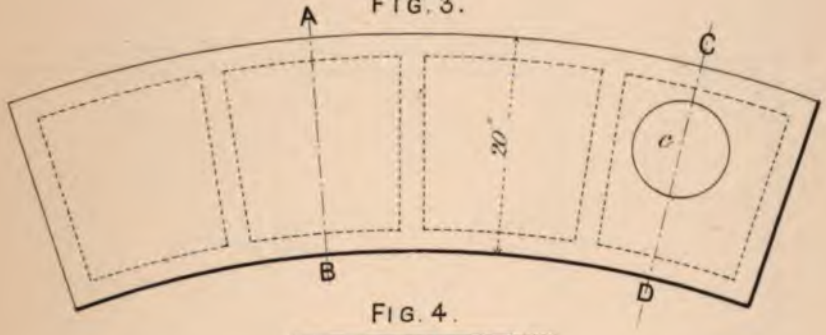
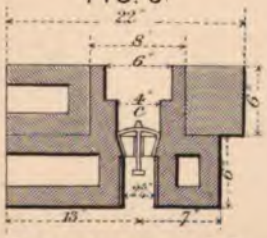


FIG. 4.

DOUBLE CRIB.

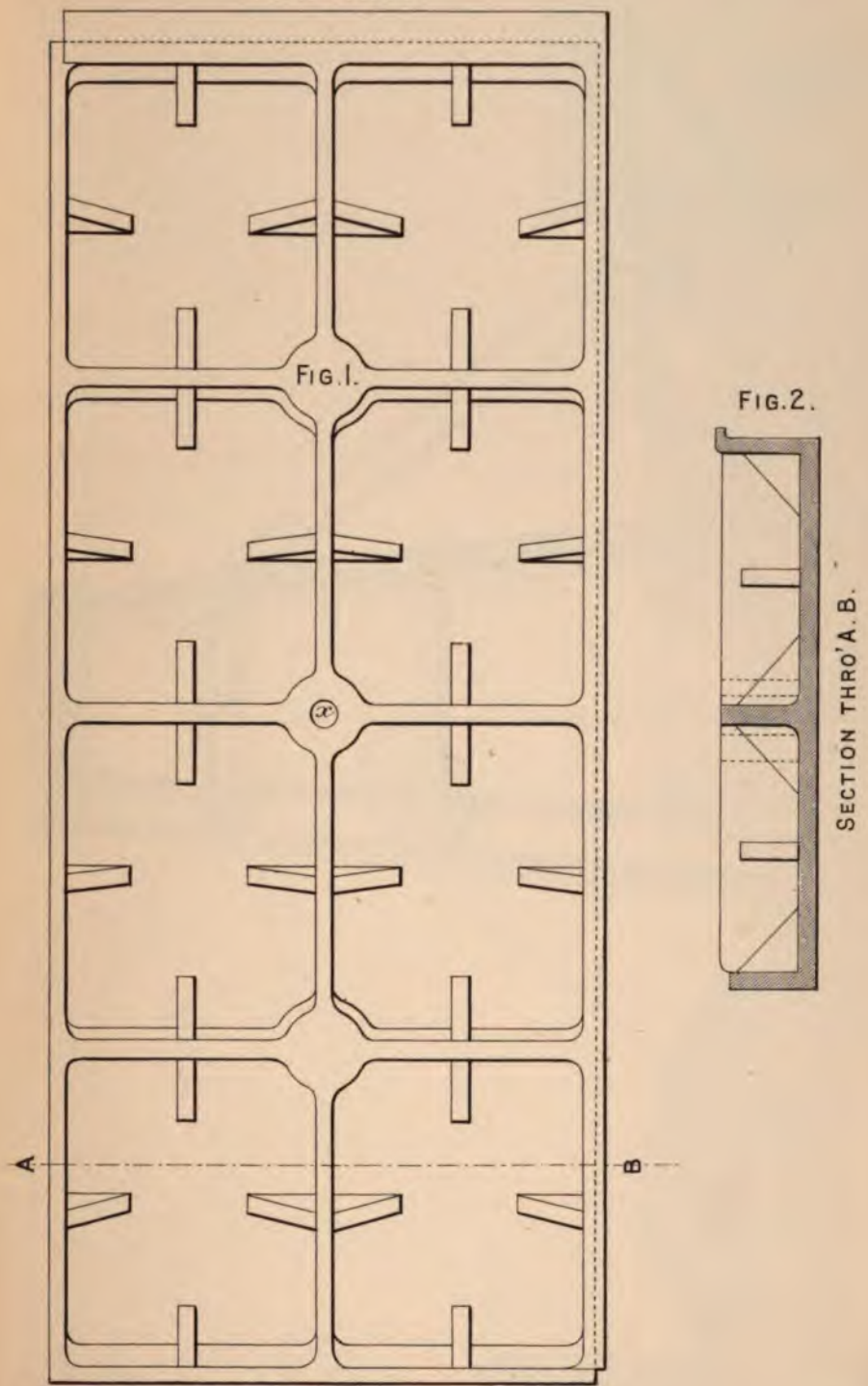
FIG. 5.



SECTION THRO' C.D.

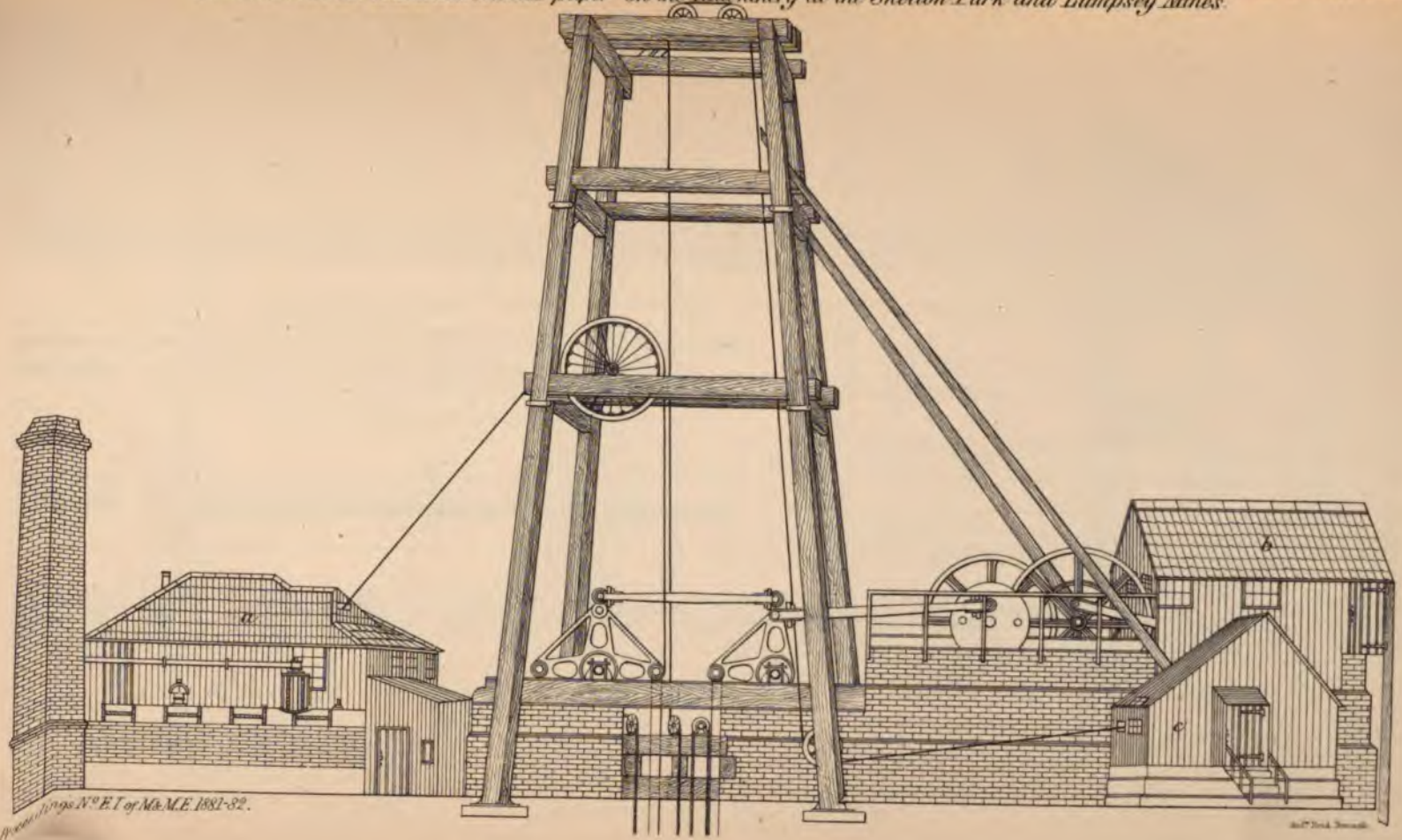
To illustrate Mr. A. L. Stevenson's paper "On the Machinery at the Skelton Park and Lumpsey Mines."

TUBBING.



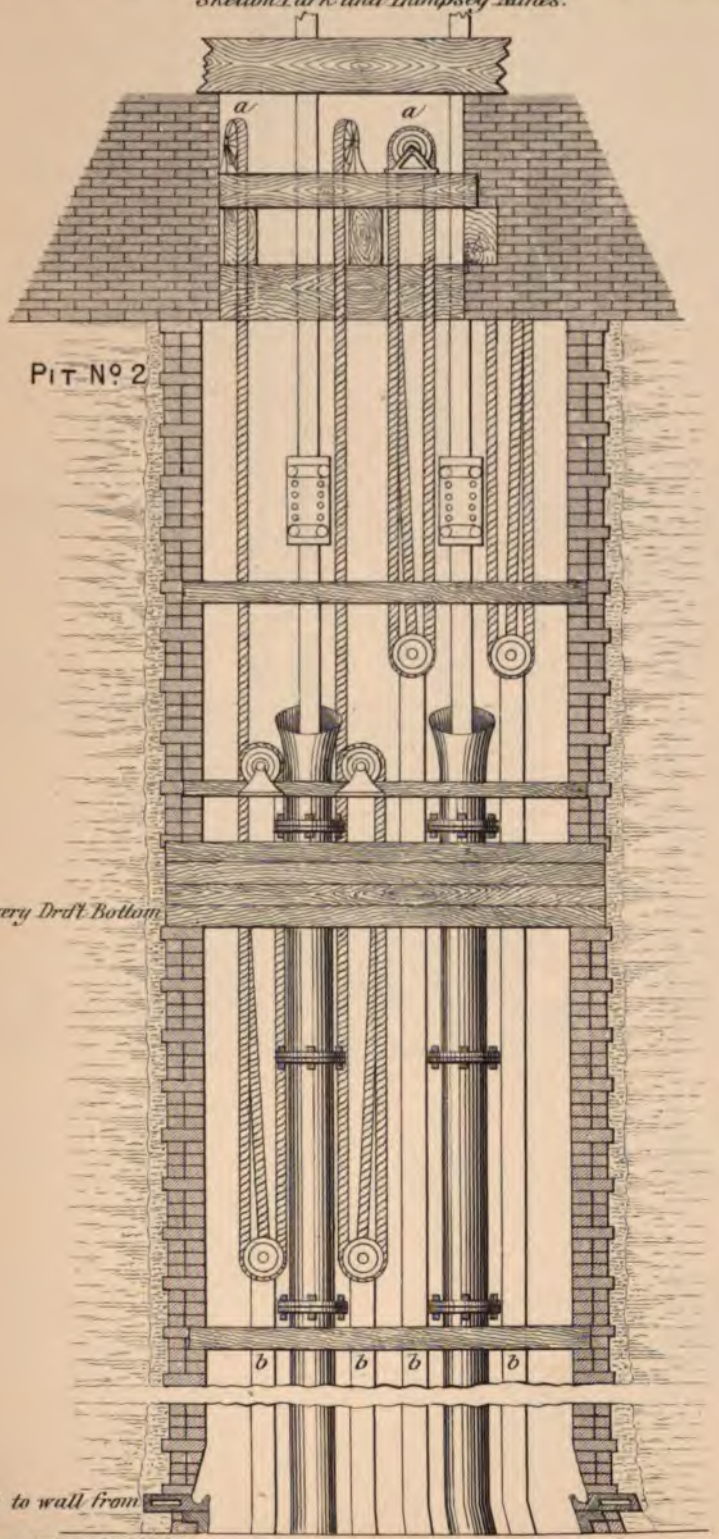
Scale 1½ inches to the foot.

To illustrate Mr. A. L. Steavenson's paper "On the Machinery at the Skelton Park and Lumpsey Mines."

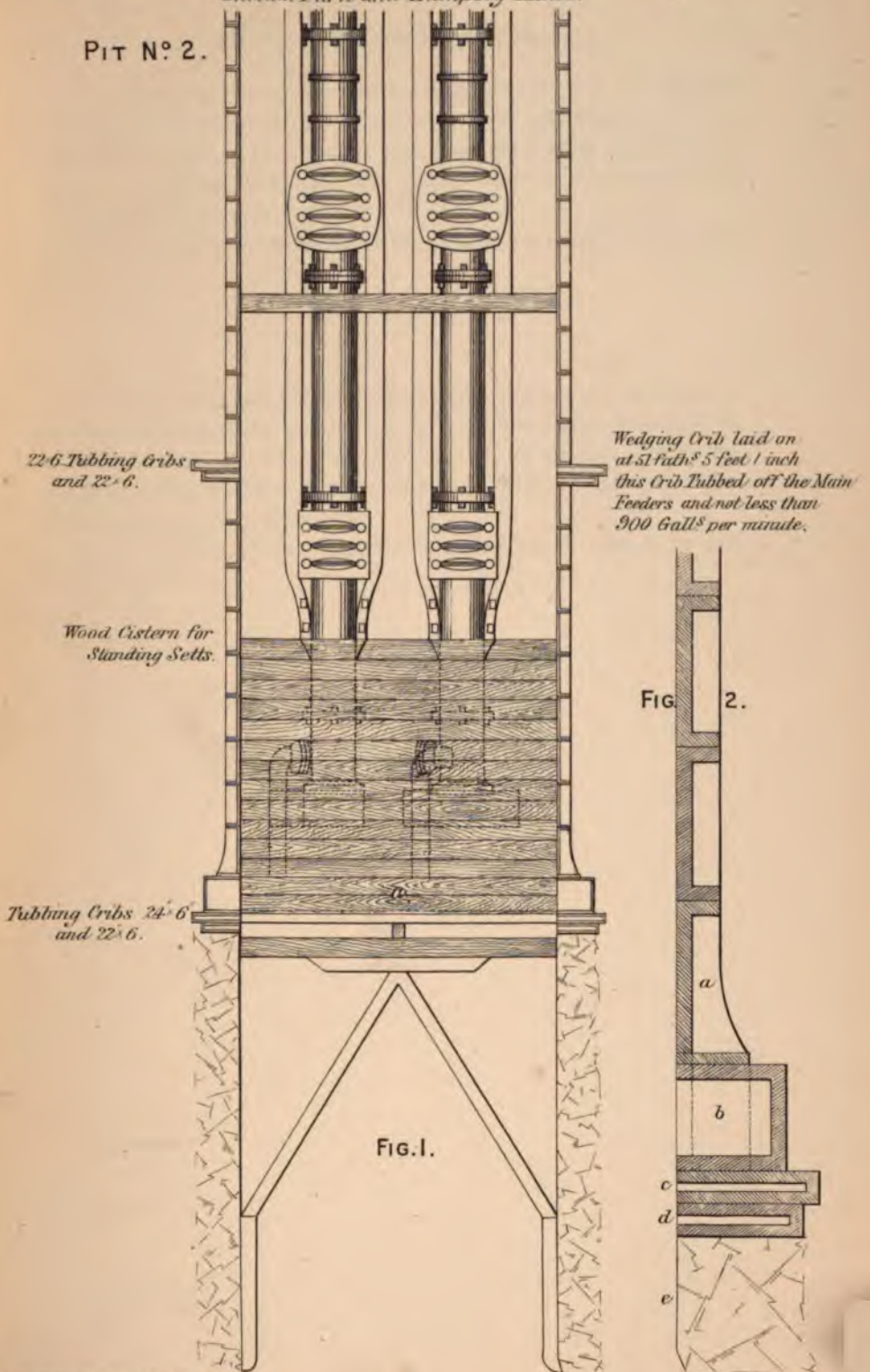


Proceedings No. E.I. of M.E. M.E. 1881-82.

To illustrate Mr. A.L. Steavenson's paper "On the Machinery at the Skelton Park and Lumpsey Mines."



To illustrate Mr. A. L. Stevenson's paper "On the Machinery at the Skelton Park and Lumpsey Mines."



The PRESIDENT was sure that every gentleman who, like himself, enjoyed the delightful visit to Cleveland, which was arranged by Mr. Steavenson, would be very glad to hear these interesting particulars of what they saw on that day. He proposed a vote of thanks to Mr. Steavenson for his paper.

Mr. E. F. BOYD seconded the motion, which was unanimously agreed to.

The PRESIDENT said Mr. J. W. Swan, who was announced to exhibit and describe his portable electric mining lamp, was unable to attend on account of illness, which they all regretted; but his assistant, Mr. Payne, was present, and would explain the lamp in the Chemical Lecture Room of the College of Physical Science.

Mr. J. BUXTON PAYNE read the following paper, written by Mr. J. W. Swan:—

ON AN ELECTRIC SAFETY-LAMP, WITH PORTABLE SECONDARY BATTERY.

By J. W. SWAN.

At a previous meeting of the Institute the writer showed an electric safety-lamp, which was the first attempt ever made, he believed, to adopt the incandescent form of electric light to the purposes of mine illumination. Since then, modifications in the form of the lantern containing the lamp have been proposed by Mr. Crompton, by Messrs. Graham, and by Mr. Jamieson. The lamp which is exhibited to-day is a still further development of the idea. Both lamp and lantern are much smaller than the original lamp shown to the Institute, in fact than any other of the same class.

The lamp, for the construction of which, in the present diminutive form, he was indebted to the skill of Mr. Gimmingham, is calculated to give the light of two or three candles. It is so attached to the conducting wires that good contact is made with them, and the renewal of the lamp can be effected with great ease.

As to the lantern, it is compact and light: it consists of but few parts, and these are of a simple and inexpensive character. It has a ring *a* (Plate XXI.) at each end for suspension in either an upward or a downward position; and there is a screw central contact *b*, to connect the lantern with the cable containing the conducting wires in communication with the apparatus generating the electric current.

In connection with the lamp there is the striking novelty of a portable electricity-generating apparatus in the nature of a secondary battery, contained in a small wooden box, which renders the safety-lamp independent of the main wires conveying the current from a distant dynamo-electric machine.

The dynamo-electric machine would, however, still be required, even with the portable cells: for what is contemplated is that the portable secondary cells contained in the box should be taken to the dynamo to be charged by its action, and that, after being so charged, these portable stores of energy should be sent into the pit workings on trucks, there to be connected with the lamps

Such a set of cells as that now exhibited will keep the lamp lighted for over one hour; probably, a set weighing about 20lbs. would keep it lighted for eight hours. When the energy of the cell has become exhausted, it can be restored an indefinite number of times by being put in communication with the dynamo-electric machine before mentioned, which may be supposed to be in a central and safe position in the pit.

The actual cost of supplying the current and keeping the lamp lighted would be very small—probably less than the cost of oil for producing an equal amount of light by means of the ordinary pit lamps. The most serious cost would be for the plant for the dynamo and engine, for the boxes of cells, and for labour in transporting them to and from the place where they were used. The writer is sorry he cannot give even an idea of this part of the cost of applying the system. It is very possible—it is even very *probable*—that the store cells may be improved, so as to render them less bulky and heavy and less costly: so much so that the writer has preferred to wait a short time before submitting drawings of them to the Institute for publication until the improvements suggested by experience have been made. The weight of the lamp is 1½lbs., and the weight of the box 9½lbs.

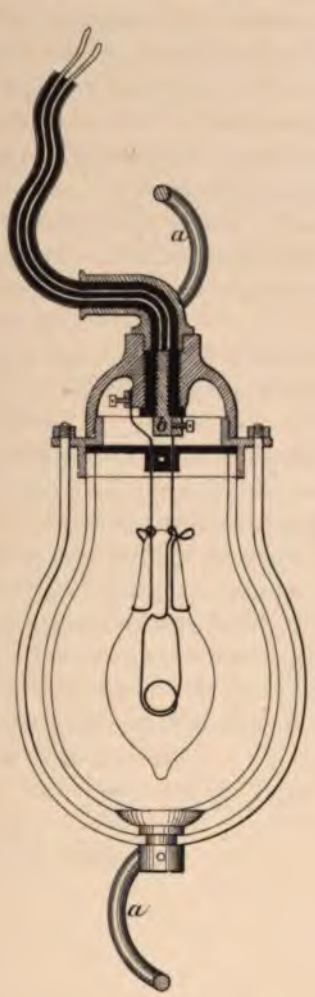
The lamp, it is hoped, will be considered much improved since the first one was shown, and be found to have reached a very practical and satisfactory form.

As regards the source of electric power, the writer realizes, almost as strongly as anyone, that the details of that portion of the scheme require further development; and one of the objects in view in exhibiting this imperfect apparatus to the members of the Institute to-day is the advantage of obtaining criticism and advice, guided, as it will be, by that practical knowledge which only miners can possess, and which is looked to as likely to be of assistance in producing a still more complete solution to an interesting and important problem.

Mr. Payne, in reply to questions, could hardly say with certainty whether, if the lantern was accidently broken in a fiery mine, it would explode gas; breaking the wire connecting the lamp to the source of power certainly would. He understood that some experiments had been made with the lamp in the neighbourhood of Nottingham which went to prove that the breakage of the lamp would fire gas; but Mr. Lindsay Wood's information did not seem to confirm this.

To illustrate Mr. J. W. Swan's description of his "Electric Safety Lamp with portable Secondary Battery."

HALF SIZE.



Mr. Ross said the lamp would be made safer by covering it with wire gauze. If the lamp was broken in its present condition the carbon would be in a white heat for a moment, and, in a suitable atmosphere, an explosion could not be avoided. If there was gauze round the lamp the flame would not pass out.

Mr. Cochrane suggested that a request be made to Mr. Swan to allow a lamp to be broken in an explosive mixture, and then they would see whether an explosion took place or not. It could be done at the expense of the Institute, and a few pounds would be well spent.

The President—One experiment would hardly prove anything unless it caused the gas to fire. It would require a great many to prove that an explosion would not occur if the glass were broken.

Professor Herschel asked whether the lamp could not be fixed permanently to the box, so that the use of wires could be avoided, and one source of danger be thus removed.

Mr. Payne said that two or three weeks ago Mr. Swan prepared a sketch, with the lamp placed on the top of the box, which would do away with wires altogether.

The President proposed a vote of thanks to Mr. Swan for his kindness in sending the lamp and preparing the description. They regretted that Mr. Swan had not been able to attend, but he had been well represented by Mr. Payne. He thought this was one step towards the practical solution of the difficulties attending electric lighting underground; and hoped it would be carried further, and that, in the end, they might have a perfect lamp, not only to afford an excellent light underground, but also to make themselves perfectly safe with it. He saw one difficulty, and that was that they would not know what sort of atmosphere they were working in until they felt the effects on their breath.

Mr. Lindsay Wood seconded the vote of thanks, and it was unanimously passed.

The meeting then separated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 22ND, 1882, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The ASSISTANT-SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATES—

Mr. GEORGE N. VITANOFF, Messrs. Hawks, Crawshay, & Sons, Gateshead.
Mr. JOHN DOUGLAS, Sen., Seghill Colliery, Dudley, Northumberland.
Mr. JOHN DOUGLAS, Jun., do. do. do.
Mr. JOHN G. A. MACDONALD, Warora Colliery, Central Provinces, India.
Mr. CHARLES COCKSON, Wigan Coal and Iron Co., Limited, Wigan.

STUDENT—

Mr. FRANCIS W. GREEN, Harton Colliery Offices, South Shields.

The following were nominated for election at the next meeting:—

ORDINARY MEMBER—

Mr. JOHN HARBOTTLE, Manager, Skelton Park Mines, Marske-by-the-Sea.

ASSOCIATE—

Mr. RICHARD L. WEEKS, Willington, Co. Durham.

STUDENT—

Mr. CHARLES FORSTER, Backworth House, Newcastle-on-Tyne.

The PRESIDENT then read the following address:—

THE PRESIDENT'S ADDRESS.

GENTLEMEN,—In addressing you to-day, my first duty is to return you my sincere thanks for the honour you have done me in electing me to the position of President of your Institution. I could have wished that your choice had fallen on some one more competent to discharge the duties of this responsible post; but I will use my best efforts to follow in the footsteps of those who have preceded me, and I trust that the members of the Institute will assist me as much as possible in my efforts to ensure its prosperity and to carry out the objects for which it was founded.

I need not say that one of the principal of these objects was the attainment of a greater degree of safety in the working of our mines; and I propose, therefore, in the first place to glance at what has been done in this direction within the last few years.

The terrible and overwhelming calamities which, notwithstanding all the scientific appliances and improvements of the present day, have continued to overtake our collieries, induced the Government to issue, in 1879, a Royal Commission to enquire into accidents in mines, and the possible means of preventing their occurrence or limiting their disastrous consequences.

The names of the Commissioners are a sufficient guarantee that the enquiry will be most complete and exhaustive; indeed the list of subjects on which the Commissioners required information, and the fact that they are personally making various investigations and experiments, show that their report will embrace all that is known on the subject or can be devised to attain the object in view.

Naturally, we are all anxiously expecting this report, but the work is evidently such that much time will be required, and it is satisfactory to know that the Commissioners are determined to carry on their researches until they have thoroughly investigated all points bearing on the subject.

They have, however, issued a preliminary report, with a summary of the evidence taken, the heads of which show the great range of their enquiry and the pains they have taken to elicit the opinions and experience of men of all classes connected with coal mining.

Before leaving this subject, I would wish to point out that the Commissioners, in alluding to the annual number of deaths caused by accidents in coal mines, observe that whilst the total number of deaths remains almost the same, the number of persons employed has nearly doubled during the last thirty years; so that, as compared with the numbers of the persons employed, the loss of life has been reduced by one half.

The Commissioners express a strong opinion that this beneficial result is to be attributed to the action of legislation and the spirit of enquiry and emulation fostered by local scientific Institutes of Mining Engineers.

We cannot but consider this to be a very high tribute to the efficiency of your Institute, which was the first of such societies, and it should encourage us to give our most earnest attention to all subjects which bear on the increased safety of our mines and their proper development and working.

In considering this question of safety, an efficient ventilation, or quantity of air, though by no means the only requirement, is certainly one of the most necessary, if not the most important; and, naturally, the first thing to consider is the best means of producing a sufficient current of air in our pits.

In the early years of the existence of the Institute, the chief discussions on this point were as to what was the best means of attaining this end, and the power to be applied for this purpose, whether furnace, fan, or steam jet.

I think we may now consider that the fan occupies the first position, except perhaps for very deep mines, where the furnace still holds its own; and the chief point of discussion during late years has been as to the best form of ventilating fan, whether it should be one acting by centrifugal force or by direct displacement of the air; whether open running, discharging direct into the atmosphere, or running in a case with a confined outlet; and whether the required velocity of the periphery is to be attained by a large diameter of fan, or by using a small fan at a high velocity.

Various papers have been read and discussed before your Institute showing the merits of the different forms of fan now in use, but it was felt that a satisfactory comparison could not be made, owing to the experiments, the results of which were given, having been carried out by different observers on different bases, and to some extent under varying conditions.

In consequence of this, a committee was appointed by your Institute to experiment on ventilating fans of several descriptions.

Under the auspices of this committee many fans were carefully and systematically tested. The results of these experiments were given in the report presented last year.

Though the committee, following the custom of the Institute in such cases, did not express any opinion as to which is the best of the fans experimented on, they have given full particulars of the working and powers of each, which will enable any one to select the form most suitable for his purpose.

It is satisfactory to observe that the difference is mainly in the economy of working, and the useful effect which in several cases was found to exceed 50 per cent.; and it may be observed that these maximum effects are obtained when the respective fans are doing the larger work. Unfortunately, in several cases, the work done was not sufficient fairly to test the actual merits of these respective ventilating machines.

Having secured an efficient ventilating power however, we have only taken the first step towards the desired end; we have, as it were, secured the raw elements of an army which it is necessary to drill and organise if it is to be of any use to us.

The first thing to be done is to get the air into the face of the workings, where it is required to combat our great enemy—gas, and to preserve the salubrity of the mine.

This very important point merits the greatest attention and care, and if not sufficiently attended to, through a deficiency in stoppings, leakages at doors, crossings, etc., will soon reduce a powerful ventilation to an insignificant current before it reaches the face, where its work is really to to be done.

The proper distribution of the air in the workings is the next point to be arrived at, and it has been carefully elaborated by general practice until it has reached the system in use at the present day.

According to the evidence of the late Mr. Buddle given before the Select Committee of the House of Lords, in 1835, the only system of ventilation known in the coal trade up to about the year 1760, was to carry the air in one current round the face of the workings, thus ventilating the extremities of the mine but leaving the centre or waste entirely unventilated.

At that time, Mr. Spedding, of Whitehaven, introduced the system of coursing the air, which, as you all know, consists in taking the air up and down the several sheths of workings, so that no particular passage or working was left without ventilation.

This was undoubtedly a very great improvement; but still the air was much impeded by the great distance it had to travel (sometimes, in Mr. Buddle's experience, upwards of 30 miles), and it was also open to the objection that in fiery mines the air became much contaminated with gas before it had completed its work, so much so that it was often in an inflammable condition when it reached the furnace.

This system continued in force till about the year 1807, when Mr. Buddle devised the method of splitting the air into two currents and conducting any explosive current to the up-cast without allowing it to pass over the furnace.

By this means the friction of the air arising from the great length of the air courses was considerably reduced, the air was brought into the face in a purer condition, and all danger of the explosive current firing at the furnace was obviated. These were the radical improvements in the ventilation of collieries, and they were followed by the adoption of the further splitting of the air, so that each district should have its own current, the different districts being at first only separated by stoppings, but afterwards in many cases by solid barriers of coal, thus isolating them from each other except at the outlet and inlet, and therefore making them more likely, though unfortunately not certain, to escape the general destruction which usually attended an explosion in workings which were all connected indiscriminately. It has been urged that in England we do not pay sufficient attention to ascensional ventilation, that is, the arrangement of the shafts and air courses so that the intake air is conducted downwards and the return rises towards the upcast, thus taking advantage of the increased temperature of the return. I think this apparent neglect arises from the comparatively level nature of the seams in this district, which does not, in fact, admit of any great advantage being taken of the application of this natural law.

However good the ventilation may be, it is evident that it cannot always ensure safety when sudden outbursts of gas take place; indeed in some cases the large supply of atmospheric air may lead to a quicker production of the explosive mixture which is often so fatal in its consequences.

Before the invention of the safety-lamp, ventilation (if we except the flint and steel mill), was the only safeguard in fiery mines, and there may be some who think that no mine should ever be allowed to be in such a state as to require a closed lamp. However true this may be as an abstract rule, every one conversant with mining knows that it is practically impossible, and that in all mines producing gas, sudden outbursts and accumulations must be guarded against.

The Davy, Stephenson, and Clanny lamps were at first considered quite safe, probably the air currents of that day were not sufficiently strong to interfere with this sense of security.

Experience has, however, shown that all these lamps will, under certain circumstances, allow the flame to pass through the protecting gauze.

It would appear that the lamps of the Mueseler type are free from this defect, as they go out at once in an explosive atmosphere, but they have the disadvantage of depending on the glass, and are also liable to go out if not carefully handled.

This subject has been thoroughly treated in your Transactions, and I only allude to it now with the view of expressing a hope that the labours and experiments of the Royal Commission will give us a standard lamp, absolutely safe, and of such a construction that it will be satisfactorily received by all who need to use it.

Various forms of safety-lamp have been invented, some of which to a certain extent fulfil the required conditions, though there is a difficulty in some of them in admitting sufficient air to support combustion, and, at the same time avoiding the danger of forcing the flame through the gauze by allowing a direct current through the lamp.

No form of lamp appears to me to be so simple and efficacious as that now largely used in the County of Durham. I allude to what is commonly called the "Tin Can" safety-lamp, which consists of an ordinary Davy lamp encased in a tin cylinder perforated at the bottom for the admission of air, and open at the top. By means of a second lock the case is firmly attached to the lamp, which gives additional security; whilst a glass, either square in the form of a single pane, or circular, allows the light of the lamp to shine through. This I consider a beautifully simple contrivance, and if the holes for the admission of the air are properly placed, it will stand the most severe tests—in fact, I believe it has never yet been exploded.

I may here remark on the importance of ascertaining that the lamp is in a safe condition before it goes into the mine, as the best lamp is, of course, useless if the slightest flaw exists in it. In addition to the usual way of examining carefully by the eye, a gas test is adopted in many mines where it is practicable, and is of great use. The simplest application of this appears to be that introduced by Mr. Embleton, of Leeds, which consists of a ring of gas pipe, in the inner side of which are bored a number of small holes. The lamp having been lighted is drawn up through the ring, and, if perfect, will not ignite the gas, but if there is any imperfection the gas is lighted at once.

Unfortunately, gas is not our only enemy in a coal mine. The effect of coal dust as an adjunct to an explosion has been for some time before us, having in fact been mentioned by Messrs. Lyell and Faraday in their Report on the Haswell explosion in 1844, but does not appear to have attracted much notice till 1876, when it was the subject of a carefully

prepared paper, read by Mr. Galloway before the Royal Society. Since this time it has received considerable attention, and during the last few years, Mr. Galloway, as well as the late Professor Marreco and Mr. D. P. Morison, have continued their investigations demonstrating its dangerous properties, and after the explosion at Seaham, Professor Abel was requested by the Home Office to investigate the subject.

The results of these experiments appear to show that coal dust in mines not only promotes and extends explosions, but that it may itself be brought into operation as a fiercely burning agent, and when mixed with a very small proportion of fire-damp, it will operate even as an exploding agent.

Professor Abel further found that dust in coal mines, quite apart from any inflammability it may possess, can operate as a finely-divided solid in determining the ignition of mixtures of only small proportions of fire-damp and air.

This is an additional source of danger in dry coal seams, and involves extra precautions.

Mr. Galloway advises a frequent watering of the roads where the dust accumulates, and this, though a troublesome operation, appears to be a remedy that can be applied in most cases.

Sometimes, however, the nature of the floor is such that the water causes it to heave and give much trouble.

Mr. Robert Stevenson recommends the use of salt to lay the dust, and it is said that even in very dusty mines a sprinkling of salt once a week for the first month, and once a month afterwards, will effectually subdue the dust and cause it to "lie like damp sand."

This beneficial effect in laying dust is also very noticeable at Tynemouth, where the streets are now watered with salt water.

The detection of the presence of fire-damp is a question of much importance in mining. The rough method of judging the proportion of fire-damp by its effect on the flame of a lamp, though the only one yet practically in use, is not generally considered sufficiently delicate when the gas is present only in small quantities. To improve on this method various instruments have been suggested and tried. In addition to those of Mr. Ansell (so frequently described) and others, new instruments have been brought under your notice by Professor Forbes and Mr. Liveing. The former depends on the principle in acoustics that sounds produced by the vibration of a tuning fork, placed over a column of air confined in a tube, become more audible when this column is of the length suited to the pitch of the note produced by the fork, and that the length of this

column is influenced by the specific gravity and nature of the various gases contained in the tube; and the latter on the different degree of brilliancy shown by two platinum wires when raised to a red heat by a current of electricity, the one enclosed by glass in a mixture of atmospheric air and the other in a mixture of air and gas.

These instruments are all very ingenious, and in the laboratory appear to give very good results, though there may be some doubt as to their efficiency in actual practice in the mine. A paper was read by Mr. Steavenson before your Institute, in which he shows that by using a dark blue glass the elongation of the flame can be much more readily observed and noted.

Messrs. Mallard and Le Chatellier, who have lately made some experiments as to the best means of indicating the presence of fire-damp, appear to have arrived at the conclusion that this can be most surely attained by a combination of observations on the action of the gas in lengthening the flame of a safety-lamp, properly constructed for the purpose, and the height and intensity of the flame cap. They state that, after some practice, even one-half per cent. of gas can be detected.

The question of the pressure at which gas in given off in a coal seam has been recently brought under our notice by the very interesting and careful experiments made by Mr. Lindsay Wood, and published in your Transactions, Vol. XXX. By boring holes in the solid face of the coal, and fixing in each a tube to which a pressure gauge was attached, Mr. Wood tested the pressure of gas as given off in the borehole. It was found that in one case the pressure was 461 lbs., and in another the flow of gas was 15·72 cubic feet per hour.

The results do not appear to show that the pressure of the gas has any connection with that due to a column of water of the depth of the borehole from the surface; indeed they are very much less; in one case only $8\frac{3}{4}$ per cent. It does seem, however, that the pressure varies for different depths of borehole, and approximately as the square root of this depth; and therefore as the gas must escape through the solid coal, it is possible that the difference in pressure may be due to such escape, and that if we could bore holes of a sufficient length, the pressure due to the column of water might be reached.

Considerable attention has of late been called to the suggested official issue of "Colliery Warnings," and it is contended that these should be sent out as occasion may require by the Meteorological office.

Without at all intending to disparage such warnings, or the good intentions of their advocates, I would observe that it is still doubtful whether

there is really any practical connection between barometric pressures and colliery explosions, as any one may observe by comparing the recorded variations of the barometer with the dates of such accidents. I admit that a sudden decrease in the pressure of the atmosphere will probably affect old workings and goaves charged with gas, but it has yet to be proved that it has any appreciable effect on the issue of gas from the coal itself, or that it is in any way connected with those sudden outbursts which produce such disastrous results.

What I would wish to impress on those who are in charge of coal mines is, therefore, that they should not depend on or wait for these warnings, but should themselves closely watch the barometer and note its changes, and above all, should have their mines in such a state of efficiency and discipline as to be ready, so far as their powers will allow, for any emergency which may arise, no matter in what form it comes.

Depend upon it no precaution should be neglected or deferred, because the danger does not appear imminent, and he who does so will most surely, at some time or other, be in the position of a general who neglects his outposts because he thinks the enemy is still at a distance. Every one should dispose his plans so that as far as possible they may meet any contingency which may arise, and never rely on the improbability of anything happening—it is often "the most unexpected which does occur."

In our consideration of questions of safety in mining, the use of gunpowder should not be overlooked.

Gunpowder, like fire, is a good servant but a bad master, and is blamed for many accidents, sometimes perhaps more than it deserves.

My view is that it should not be indiscriminately forbidden. I am fully alive to the fact that in some mines which are very fiery, its general use may be attended with risk, and in these it may be a question whether it should not be either abandoned or at all events only used on important occasions and under very stringent rules.

But surely there are many degrees of difference between the danger of our most fiery mines and those which practically produce no inflammable gas. It must be evident that in many cases there is really no danger in using powder with proper care and precaution, and I see no reason why in these it should not be continued, whilst there can be no doubt that there are many such mines, which, as far as our knowledge at present goes, could not be carried on without it.

Blown-out shots, though not very frequent in this district, are no doubt a source of danger if in the vicinity of any explosive mixture.

In reference to this subject, Mr. Galloway's experiments show that the

sound wave produced by the explosion of a charge of gunpowder is sufficient to force the flame through the gauze of a Davy or Clanny, though not through that of a Mueseler lamp. It is satisfactory, however, to know that this only occurs when the charge of powder is exactly the quantity required; an overcharge puts out the flame, and an undercharge does not pass it through the gauze of the lamp.

Many suggestions have been made with the view of minimising as far as possible any danger which may arise from firing shots, amongst which perhaps water-cartridges are the most ingenious. In these a charge of powder is surrounded by a casing containing water, which, on the shot being fired, is burst, and the water thus liberated is said not only to prevent all flame but also to increase the effect of the shot. This, however, is doubtful.

A system of using compressed lime instead of gunpowder has lately been made public by Mr. Sebastian Smith, of Shipley Colliery. In this, lime in a caustic state is employed. It is ground to a fine powder, and consolidated by a pressure of about 30 tons into the form of cartridges $2\frac{1}{2}$ inches in diameter, having a groove along the side. When the shot-hole has been drilled, the lime cartridge is introduced, together with a small tube through which, after the usual tamping, water is pumped.

It is said that the water thus supplied at the far end of the shot-hole causes the lime to expand and brings down the shot in about two minutes. In some experiments made in Derbyshire and recently published, this system is said to save above 30 per cent. of labour as compared with the getting of coal by wedging.

If this system should turn out a general success, I need not say it would be a great boon to all who are working fiery mines.

It may be asked why mechanical means have not been introduced as a substitute for the explosive gunpowder—and indeed these have not been neglected. There are many machines which have been brought out to meet this difficulty. Amongst others may be mentioned those of Messrs. Bidder and Chubb, the ingenuity of which deserves very great credit. I regret, however, that they do not appear sufficiently simple to have as yet come into general use. I think this is a subject deserving our great attention, and I should rejoice very much if, by further improvements in such machinery, the difficulty of shot-firing could be overcome.

The question of the proper area of coal to be worked to one pair of shafts has occupied considerable attention of late years.

In the early days of mining, the work was naturally commenced at the outcrop, and even when pits were necessary they were so shallow that

another could be economically sunk before the workings had reached any great distance from the first, it being then easier to sink a shaft than to convey the coals a long distance underground. But as the coal near the outcrop became more and more exhausted, it was naturally found that, to meet the increased cost of sinking and plant, it was necessary that a constantly extending area of coal must be won and worked by one establishment, until, through the improved means of underground haulage and ventilation, we have at the present day workings extending to such distances from the shaft as would in former times have been considered quite impossible.

It is not contended that any danger arises from the mere increase of the distance to which the works extend, for I am not aware that any casualty can be ascribed to such distance, and in fact we know that some of the most severe explosions have occurred in pits only opened out to a very moderate extent, whilst other collieries have been worked to exceptional distances without any such misfortune, and there does not appear to be any reason why they should be more unsafe than others; in fact, the extending ramification of the workings, increasing in all directions, seems to drain off the gas.

That there can be no engineering difficulty in working mines to distances even much greater than those as yet attained must, I think, be admitted by all conversant with the subject, and the fact that two companies are proposing to commence to form a tunnel under the Channel to connect England and France, a distance of at least ten miles to mid-channel, fully shows that the most experienced engineers of the day have no doubt of it.

The only tenable objection is, that the system of working large areas entails a corresponding increase in the number of men employed, and consequently in some cases a greater loss of life when any severe explosion unfortunately occurs.

This is, I need not say, our necessity rather than our choice; it is plain that we would not employ such a method if the old one was still practicable, but it is not, and I have no hesitation in saying that any restriction in this sense would seriously affect many important undertakings.

The tendency of the age is in the direction of large results, and to limit this development of mining enterprise would be, in my opinion, on a par with requiring our present magnificent ocean-going steamers to be replaced by the small craft of former days, or that stage coaches should again take the place of express trains.

One of the most distressing effects of a heavy underground explosion is, that in many cases, the explorers are unable to proceed in consequence of the presence of large quantities of gas.

Many valuable hours, and even days, are thus lost to those who are endeavouring to succour their comrades. Mr. Fleuss's inventions promise to assist us very much in these cases. This apparatus consists of a mouth-piece, or mask, connected by flexible tubes with a strong sheet copper cylinder, carried on the back of the explorer, in the form of a knapsack.

The cylinder contains four cubic feet of oxygen, compressed to sixteen atmospheres, and above it is a square metal box, containing the carbonic acid filter, which consists of layers of caustic potass, by passing through which the exhaled breath is freed of carbonic acid. An india-rubber bag is fastened in front of the wearer, and is connected by a pipe to the outlet of the filter, being also in communication with the reservoir of oxygen, the supply of which to it is regulated by a valve under the control of the wearer.

The mask, which fits air-tight to the face, has two flexible valve pipes, the one being in communication with the inlet of the filter, and the other (for inhaling) with the air bag.

The exhaled breath having passed through the filter, enters the bag in a purified state, and being there supplied with oxygen, is fit to be breathed again.

In this way, the explorer can continue his advance quite independent of the condition of the air surrounding him. The plan has been severely tested, both experimentally and in practice, and is found to be quite safe. It was used at Seaham, during the re-opening of the Maudlin Seam, after the explosion of 1880. The greatest care was here necessary, owing to the coal having been on fire, and the consequent danger attending the carrying in of fresh air.

The men using the apparatus were able to penetrate to a distance of 400 yards in advance of the air, and were, in fact, in an atmosphere of carburetted hydrogen for all that distance.

Since this was written it has also been used at the recent accident at Killingworth, and was there found to be of great service.

In connection with this, Mr. Fleuss has also a lamp constructed on similar principles, which it is necessary to use when exploring with this apparatus, for, of course, no ordinary lamp could be of any service in such a case. It is a modification of the lime light, spirits of wine being used instead of hydrogen.

Attached to the lamp is a strong copper sphere, charged with oxygen,

at a pressure of 16 to 20 atmospheres. A minute stream of oxygen, regulated by an adjusting valve, is allowed to pass between the two wicks of the spirit lamp, carrying the flame against a cylinder of lime.

The lamp being entirely cut off from the surrounding atmosphere by the double copper casing, with water between the inner and outer services, throws its light through discs of plain glass inserted in the casings, and is, of course, absolutely safe. It will burn four hours, equally well in carbonic acid gas or in fire damp.

This lamp was found to be of great service in the Seaham exploring. Its light is so powerful that a newspaper can be read at a distance of 40 or 50 yards.

It has also the advantage that it will act equally well under water, but unfortunately its size and bulk prevent its being used for ordinary purposes in the workings.

It is not solely to the large explosions of gas that we owe the accidents which attend our course in mining.

Minor accidents, sometimes fatal, and, if not so, often involving serious bodily injury, must always occur in a greater or less degree, though it is confidently hoped that every year the care and discipline, both of managers and workmen, will tend to diminish the number.

There is one thing bearing on this which I would wish to point out to you. It is this—that these accidents generally occur at some distance from the shaft, and necessarily a considerable time must elapse before the injured person can be brought to the surface and receive medical assistance.

Fortunately there is a very simple remedy for this difficulty. It is the formation at each colliery or works of ambulance classes. This has been done in several places with great success, under the auspices of the St. John's Ambulance Association. It is a good work, and I would commend the system most earnestly to all colliery managers and workmen.

It is astonishing how much can be taught in a few lessons with the aid of the resident doctor, and there can be no doubt that if all officials and workmen would apply themselves to acquire the knowledge of what should be done in case of injury, before the doctor is reached, much pain and suffering, and possibly some loss of life, would be avoided.

Probably no subject has ever occupied the minds of the scientific world so much as that of electric lighting during the last few years. You are all familiar with the great development which has recently taken place in the application of electricity to lighting purposes in our streets,

theatres, and other public buildings. It is of course out of my province to speak of its general application to-day, but I may perhaps be permitted to observe on a few points in which it bears on the management of our mines.

Last year, the Royal Commissioners had some experiments tried at Pleasley Colliery, by lighting up the roads and workings with the electric light, and, since then, Risca Colliery, in Wales, and Garnock Colliery, in Scotland, have been lighted by the same means.

These are, however, only examples of the ordinary lighting, and have not as yet demonstrated its applicability to be used in the safety-lamp for which we are all anxiously looking.

Hitherto, the great drawback as regards the safety-lamp has been the fact that to carry with it the means of keeping up the light or to keep it in communication with the source of the electric current, required an apparatus too cumbersome to be brought into daily use.

A great advance has, however, been made in this respect during the last year. M. Faure has shown that the energy required to produce the electricity can be stored and carried about from place to place; or, if the storage cell is kept stationary, it can be easily charged from time to time through wires connecting it with the dynamo-electric machine—acting in fact in the same way as the gasometer in the gas lighting system, and the accumulator in a hydraulic power system.

Our townsman, Mr. Swan, whose achievements in this branch of science are familiar to you, and who has further improved on M. Faure's system, recently showed us a miner's lamp, having a storage cell attached to it, which contained sufficient energy to supply the electricity required by the lamp for a period of one hour.

This, though enduring for too short a time, is, I consider, a very satisfactory step in the right direction, and the experience of last year shows that many powerful minds are working on this subject, and that we may expect still further improvements in all appertaining to electric lighting.

I am aware that there are two objections to the use of electricity in a safety-lamp; first, that if the glass of the lamp were broken the light might explode the gas; and secondly, that any interruption of the current, such as might be caused by the breakage of a wire, would produce a spark which might cause a similar accident. But I am in hope that before long these difficulties will be overcome, and that Mr. Swan's miner's lamp will put us in the position of obtaining a safe and effectual method of lighting our mines—safe as it is entirely isolated from any contact

with the air, and effectual as it would without doubt afford our workmen a very much greater amount of light than any lamp now in use.

And here I would observe that there is another way in which I think the use of electricity may be of great service in mining.

Instances are constantly occurring in which, from various causes, it is absolutely necessary to apply power at points often far distant from the shaft.

At present, this must be done by compressed air, hydraulic power, wire ropes, or by carrying steam to the place in pipes.

To all these systems, and especially to the last, there are objections, and I see no reason why an improved substitute should not be found in electricity, which can be conveyed by a wire, probably with less loss of power; and, if sufficient storage cells are provided at the far end, I think the power may be applied very economically.

The surplus power about a colliery could be utilized in this way. Hitherto, the fatal objection to its use for this purpose has been the absolute regularity required in the motion of the engine working the dynamo-electric machine. Now that it has been found practicable to store the energy, however irregularly produced, and then to give it off with the greatest steadiness when needed, this objection no longer exists, and we may take advantage of it both for the purpose of producing light and working engines at a distance from the shaft.

The necessity of providing a thoroughly scientific training for mining engineers has long been acknowledged. Probably, no country can afford a better prospect of acquiring a practical knowledge than our own; but it must be confessed that the admirable system of national technical education so prevalent on the Continent, is not carried out to its full extent in England. The legislature obliges a manager to pass an examination before he is allowed to have the responsible charge of a mine, but it provides no means by which he can acquire the requisite knowledge. There are many who think there should be a still higher grade of examination, and should this view ever be adopted, I think it will clearly be the duty of the Government to establish proper mining schools throughout the kingdom, in which our young men may acquire a thorough training for their profession. A committee appointed by the Government, is at present investigating the whole subject of technical education, and has recently issued a preliminary report. In this, however, they deal chiefly with ordinary education in France and with the efforts now being made in that country to provide technical schools, with workshops attached, in which the pupils receive instruction in various handicrafts, in lieu of serving an apprenticeship.

The full report of their investigations will be looked for with great interest.

In the meantime, it is gratifying to observe that voluntary effort has stepped in in various places to supply the deficiency, and good schools have for this purpose been established in several localities.

In reference to this I would congratulate you on the appointment of a Professor of Mining at our own College of Physical Science in Newcastle. This has been accomplished with the aid of the coal trade of Northumberland and Durham.

The progress of the College must always be a matter of the greatest interest to our Institute, both from the beneficial results it produces, and on account of the active part taken by the Institute in its promotion. I fully hope and expect that this new professorship will supply a want long felt, and will, for this district, do away with the deficiency I have spoken of.

Our recent visit to the mining district of the north of France and the Paris Exhibition must have convinced us that the science of mining is making rapid strides on the Continent. It is very important that we should keep ourselves conversant with what is going on there, and I am glad to see that your Council have determined to publish, from time to time, abstracts of foreign papers on mining and engineering subjects, which will, I think, add considerably to the value of the Transactions.

Turning now to the general question of colliery management, I am not aware that any great change has taken place of late years in the systems of working. These naturally vary considerably in different districts, but in the north, though board and pillar is still the ruling method, I think it may be said that long-wall has been gradually making headway against its old rival, and no one who has seen the beautiful long-wall faces of the Midland Counties and the simplicity of their face ventilation can wonder at it. It is more especially advantageous in working hard coal, where, by decreasing the amount of powder used, it contributes to obtaining a larger percentage of round coal.

There are, however, certain of our customs and habits which impede its progress. Workmen, as well as managers, must be educated to it, and this cannot be done all at once. I have no doubt, however, that it will maintain its ground, and, in fact, I think many of our thinner seams, especially where the production of a large percentage of round coal is essential, cannot be worked economically in any other way. It is very important for the welfare of the country at large that we should make the most of our coal riches, which not only cannot last for ever, but which

must be more difficult and costly to work as the better seams are exhausted, and all parties should heartily co-operate in working out the system which is found to be the most suitable for this end.

In sinking, the chief advance has been made in the introduction into England of the Kind and Chaudron system of sinking, or rather boring out a shaft by means of a trepan or boring tool, worked by wooden rods or spears. This is of course only applied in cases where the feeders of water are so large as to render difficult the application of the ordinary method of sinking by hand with a set of pumps suspended in the shaft. The new winning at Whitburn is a remarkable example of this. Here the feeders amounted to 12,000 gallons a minute, and when the ordinary sinking was being carried on, the water, on any stoppage of the pumps, rose 6 feet in the shaft in a minute, so that it was considered practically impossible to continue on the old system; but by the adoption of the Kind and Chaudron method, the pits were sunk through the water bearing strata of the magnesian limestone without any extraordinary difficulty.

The fixing of the tubbing after the shaft is sunk is remarkable for its efficiency and simplicity. When a bed of rock, impervious to water, has been reached, the cast iron tubbing, formed, not in the ordinary segments, but in rings properly faced and bolted together, is lowered in for a certain distance from the top by means of rods and screws, the lower end being closed by a diaphragm or false bottom, which causes the tubbing to be eventually supported by the water, whilst the proper equilibrium is maintained by the admission of a certain amount of water into the cylinder as it goes down.

The water-tight joint between the tubbing and the rock is formed by the lowest ring being rather less than the one above, which thus slides on it, and compresses a wall of moss previously packed tight against it and held in its place by a net.

By this means the pit is sunk, and the tubbing placed in its permanent position, without interfering at all with the water through which it passes, and which, ordinarily, is the source of so much difficulty and expense.

In some cases, indeed, this would seem to be the only way of sinking, as, for instance, at Marsden, a gullet, 10 feet wide, occurred at the depth of 35 fathoms, which, of course, would have given out an enormous feeder of water.

In a sinking now being carried on at Ghlin, near Mons, the depth to be tubbed off is 150 fathoms, and I need not say, that at that depth, pumping from a sinking pit would be attended with the greatest difficulty.

In prospecting for coal and other minerals, the Diamond boring system

continues to be extensively employed, though there are some who still think that in boring through seams of coal the change in the nature of the stratum can be more readily detected by hand boring.

No doubt both systems require trained men to give accurate results. In the one we depend on the delicacy of touch of the man who holds the bracehead; and, in the other, the change is detected by the eye of the attendant who watches the machine, and can tell, by its peculiar action, when the coal is reached.

In very deep holes, however, every one must acknowledge the great use of the Diamond Borer. Mr. Vivian, in our discussion on the subject, stated that he had bored a hole 1,050 yards, and from the seam found at that depth had brought up solid cores 5 inches diameter and 6 or 7 inches long, and as the solid core brought up is generally from 50 to 70 per cent. of the whole thickness of the seam, the result in this case must be regarded as highly satisfactory.

The great extension of colliery workings, as regards the depth of shafts, the distance coals are to be brought underground, and the quantities worked daily, has naturally given great scope to the mechanical engineer in designing machinery suitable for the work required. This is evident to any one who remembers the simple engines of the past and compares them with the superior class of machinery now in use, both for pumping and winding. Formerly, the expense of steam was a trifling item in the working of a colliery, but now it is absolutely necessary that every economy should be practised in this direction. The cut-off systems of MM. Audemar and Guinotte, and that known as the Sultzer Martin, have been described in your Transactions, and the difficulties attending a varying cut-off in winding engines seem to have been overcome in the engine erected by Mr. Daglish at Silksworth. The introduction of the scroll drum, with a diameter varying in accordance with the position of the load, has been of great service in the case of many deep shafts.

A counterbalance of some form or other, to aid in equalising the load at different points in the shaft, has been deemed a necessity in most places of any considerable depth, and that recently introduced in the Midland Counties appears to merit consideration from its simplicity and efficiency.

The method adopted is to fix the one end of a rope, of similar weight to the winding rope, to the bottom of each cage, so that when one cage is at bank the rope under it hangs in the shaft into the sump, and there passing round a pulley is bent up and attached to the bottom of the other cage. It is evident that by this means the variation of the weight of the ropes attached to the two cages is effectually counterbalanced, and the

load is the same at all points in the shaft, the rope below the cages acting to assist the engine at the start and also acting as a brake when the ascending cage is nearing the surface. It is said to be very effectual, and those who have used it express great confidence in its benefit and safety. It is, of course, similar in principle to the old chain counterbalances which were formerly used in Wales to regulate the working of the cages in pits where the load was raised by means of water run into a tank below the descending cage and allowed to escape by an adit at the bottom. Its application, however, to rapid winding with steam is a novelty, and seems to be a success.

A further development of this is to do away with the winding drum altogether, and substitute for it a simple pulley or sheave, round which the rope passes as in an inclined plane.

In this way only one rope is used. It has been applied, I believe, on the Continent, and is said to work very well and economically, but of course it must be open to the objection that in case of accident or breakage both cages must go to the bottom.

Whilst speaking of the economy of power, I may mention the beneficial result of using properly-constructed boilers placed on the flues of coke ovens.

By this means not only a great saving of fuel and labour is effected, but the smoke which formerly so disagreeably defaced a coking district is entirely avoided.

This improvement is adopted, I think, at all coking establishments of recent construction, and in some, engines collectively of above 200 nominal horse-power are driven, under ordinary circumstances, without any aid from hand-fired boilers.

Compressed air, as a motive power, continues to be increasingly applied in underground works. One of the principal improvements in this has been the use of single-acting cylinders for the compressors, and the introduction of a spray of water, whereby the cylinder is more easily kept cool, and the efficiency of the engine much improved.

Safety-hooks for winding appear to be coming into more general use, and are thought to be a great improvement, though I doubt the policy of making their adoption compulsory. It is objected by some, that they make the enginemen more careless, through trusting too much to them, and that there have been more cases of overwinding since they came into use. This may be, though I am inclined to think the idea may arise from the fact that where a safety-hook is used, every case of overwinding, however slight, requires some trouble to put things right again, and must,

therefore, be noticed and reported. In any case, it is a question whether the system, even if it does involve this objection, does not afford increased safety to life, which more than compensates for any amount of trouble arising from the above cause.

Safety apparatus to be attached to cages has not made the same progress as safety-hooks, and, as a general rule, we still depend on good ropes and frequent examination of them. Whatever may be the future of this question, I think it is most imperative that all winding tackle should be kept in the highest state of efficiency, and above all, that the ropes used should not be kept on too long. I should be very sorry to think that any appliance might be introduced which would lead us to run the ropes for a longer period than we are sure of, and to depend on safety-catches in case of accidents.

In underground haulage the adoption of the system of the endless chain appears to be gaining ground, and lately wire ropes have been, in many cases, advantageously substituted for the chain on the top of the tubs. The rope is made to fall into a V, or crook, which is placed on a cranked movable pivot, and, as soon as the rope enters the crank, it is pressed to one side and the V firmly clutches the rope.

The endless chain, or rope, which may be said to have been introduced into this district, through the Report of the Tail Rope Committee, in 1867, is, no doubt, a very economical system of haulage. The power required is small compared with that used in other systems, and the wear and tear of tubs, etc., is very much less, whilst the cost of formation is much reduced, as the irregularities of the road do not interfere with its action, and, therefore, much of the expense required in other systems of haulage to produce a comparatively uniform gradient is avoided.

Coal-cutting machines, though employed in several mines, have not come into such general use as was at one time anticipated.

There does not, as yet, appear to be a great saving of actual cost in their application, and, no doubt, to introduce them into old and extensive workings entails a considerable amount of expense and inconvenience. I trust, however, that we may see a further development of this method of working the coal. All machinery which effects a saving of manual labour is eventually an advantage, both to the employer and workmen, and I venture to suggest that a further investigation of this subject by your Institute would be desirable.

The application of mechanical drilling is, no doubt, extending, and is successfully used in many forms, from the simple hand drill, turned by manual labour, to the elaborate boring or tunnelling machine of Beau-

mont, now working in the preliminary operations of the Channel Tunnel, which bores out a circular drift, 7 feet in diameter, at the rate of 15 yards in 24 hours.

The common hand-drilling machine enables a man to increase his effective work by at least 30 per cent., and, in the case of the drilling machines used in the Cleveland ironstone mines, and worked by compressed air, I am informed that the actual time of drilling is under one-twentieth of that necessary for the same operation by hand, and including the time spent in re-fixing the machine, it is only one-sixteenth.

The increase of temperature as the depth from the surface increases necessarily affects the working of deep mines, and is generally considered the cause which will limit the depth to which mining operations can be carried.

The Royal Coal Commission took it at 1° F. for every 60 feet in depth from 50 feet below the surface, and from that they deduced the opinion that, allowing for the cooling effect of ventilation, a depth of 4,000 feet might be reached.

Since the date of this report, many further experiments have been made, but, as explained by Professor Lebour in his recent paper on this subject, in the greater number of good sets of observations the increase appears to be 1° F. per 50 or 60 feet.

Professor Lebour explains the difficulties experienced in taking accurate observations, and further asks for the assistance of members of the Institute in taking observations in coal mines under the sea, which I feel sure will be willingly given to him.

Some modifications have been recently made in the Rules of the Institute respecting the number of meetings to be held in the year, which it is hoped will work well, and will tend to increase the interest taken by members in the proceedings.

The object of this and all similar institutions is to promote the interchange of thought and experience amongst the members, and so to give to each the benefit of the collective powers of the whole.

Union is strength in this as in other cases, and I desire in concluding my remarks to express an earnest hope that every one will, to the best of his abilities, assist by writing papers, taking part in the discussions, and in other ways contributing to the efficiency of the Institute.

Its purpose every one will admit is to benefit all classes; its only opponents are danger and ignorance, and its only reward is the knowledge that it is labouring for the good of all who are brought within the scope of its operation.

Mr. E. F. Boyd said, they ought not to omit to pay a compliment to their worthy President for the very eloquent and instructive address which he had delivered, it seemed to embrace almost every subject connected with their intricate and difficult business—a business which had recently been shown to be one of great labour, and requiring the greatest endurance on the part of those engaged in it. Their President's address would, he hoped, direct the attention of those who had heard it, and also of those who might read it, to the number of minute details which many were so apt to forget it was incumbent upon them to study. Those who contented themselves with having stored a certain quantity of knowledge, and who, when they heard a paper on a department of work read, thought the consideration of the subject was ended and closed, and that they had got all the knowledge they could, he trusted would reconsider their position, and become thoroughly impressed with the necessity of making continued progress in their business, and of directing their best energies to the study of all details of the very varied subjects they were constantly called upon to decide. He had the honour of being one of the earliest members of the Institute, and was present, together with their late revered President, Mr. Nicholas Wood, at its commencement, after an accident at Seaton, and it gave him great pleasure to see it successfully pursuing its useful career under the guidance of a practical engineer so respected for his talents and experience as Mr. Forster; and he proposed a vote of thanks to the President for the very admirable address which he had delivered.

The motion was seconded by Mr. Armstrong, and unanimously agreed to.

On the motion of Mr. E. F. Boyd, seconded by Mr. W. Cochrane, it was resolved that the Address be printed in the Transactions of the Institute.

The following paper, by Mr. R. Stevenson, on "The Use of Salt for Laying Dust in Mines," was read:—

ON THE USE OF SALT FOR LAYING DUST IN MINES.

By ROBERT STEVENSON.

It may be now considered as an acknowledged fact that coal dust in a fiery seam is an element of danger, since Professor Abel has shown that it may, with an almost inappreciable quantity of free carburetted hydrogen gas moving at a high velocity, explode at a Davy-lamp; and this the experience of the writer fully proves; so that to render coal dust neutral in explosions, not only must it be prevented from mixing with the free gas of the mine, but it must be prevented from mixing with the ventilating current.

In all fiery seams a strong current is needed to sweep out the gases of the mine, and the deeper and more extensive the coal winnings are carried, the more necessary it becomes to increase that velocity, more especially if the present system of exhaustive ventilation continues; and the more that velocity increases, the more dusty, and consequently the more dangerous, will mining become. In fact, the point seems now to have been reached when an increase of ventilation will produce an increase in danger, unless coal dust can be prevented from mixing with the air current.

Wherever coal-cutting in narrow places continues, especially in the rich carbonaceous or coking coals, there dust, in ever-increasing quantities, will accumulate in the atmosphere of the mine until it is so loaded that it becomes almost suffocating.

To work and use blasting agents in such a mine is, if anything, even more dangerous than if the work and blasting were carried on in a huge gasometer filled with gas.

To find a reliable means of damping, or laying the dust, has caused the writer to make several experiments, all of which except the last were more or less unsatisfactory.

The most fiery seams in this district (North Staffordshire), are the famous Bambury Seams, called the Seven-feet, Eight-feet, and Bulhurst coals.

Professor Abel in his experiments found the dust of the Seven-feet, as taken from the notorious Leycett Colliery, to be the most explosive of all the samples of coal dust he had experimented with; and the writer having under his charge some workings in that seam, which for several reasons could not be worked profitably on the long-wall system, the coal-headings had to be carried out to the extreme end before coal-getting could begin, and the coal being shut out by faults from any higher workings where the gases might have escaped, water found its way into the coal to replace the exuded gas, and the workings were for these reasons rather hot and dry, and the dust was simply abominable.

Sweeping and showering water along the roadways and headings were tried to no purpose.

The angle of dip of the seam was about 45° or 1 in 1, and consequently any method which might be adopted was comparatively expensive, but the dust nuisance was so intolerable that it was determined to lay it at any cost.

The water cure was persisted in for some time, but the result was most unsatisfactory.

Unless all the roadways were previously swept, and even then, the heat and the velocity of the air current seemed to make the water evaporate almost as quickly as it could be sprinkled on, and if the floor was drenched the fire-clay began to heave and give much trouble.

Having provided a quantity of soiled salt for the pit banks early in the winter, and happily not requiring to use it for that purpose, it was tried as a substitute for water. The use of water had been stopped for a month before the salt was tried, and there was a pretty large accumulation of coal dust in the mine.

The salt was scattered on the top of the dust so as to try it under the worst possible condition, and the first day it was very disagreeable to the trolly lads, and the colliers complained very much. However, it was not long before a great improvement was effected; heaps of dust—which with the least disturbance used to rise in clouds and float along in the air current, blinding and half choking every one who had to breathe in the obnoxious atmosphere—will now lie as still as damp sand, and even when kicked about, the air current does not in the least carry it away.

The writer considers, therefore, the use of common salt, sprinkled in a powdered state, over and along the roadways of a dusty coal mine, has been proven to absorb sufficient moisture from the air of the mine as to become a most efficient and reliable means of preventing the dust from mixing with the ventilating current; and, if used intelligently in quanti-

ties of one ton per 500 yards of 6 feet roadway once every week for the first month, and once a month afterwards, the working in fiery mines will henceforth be rendered more safe and pleasant.

In the North of England refuse salt is not to be had in any quantity, but foreign ground rock salt can be obtained at from about 13s. to 15s. a ton *ex* ship, which, if well moistened with water, will prove as effectual as that used by the writer.

The PRESIDENT said, that this was a very important subject, and he was pleased to see that Mr. Galloway, who had taken much interest in the subject, had kindly come all the way from Wales to take part in the discussion.

Mr. GALLOWAY said that, as they could easily imagine, he had taken a very great deal of interest in this subject. About a month ago, when he first heard of Mr. Stevenson's use of salt for the purpose of laying dust, he entered into correspondence with him, and arranged to visit the colliery and see the results for himself. Accordingly, on his way to the north, he visited Mr. Stevenson's mine yesterday, and found that some part of it was flooded with water which prevented his entering the workings where the salt had been placed. He learnt from Mr. Stevenson that salt was being applied at the adjoining colliery of Haresfield, and, accompanied by Mr. Stevenson, he went into the workings where salt was on the road. The shaft at Haresfield Colliery was 160 yards or 80 fathoms deep, and the place where he saw the salt applied was close to the bottom of the downcast. At that point, about 100 yards of road had been sprinkled with the salt of the district. He brought with him to the meeting a specimen of the salt. The amount of salt sprinkled on the 100 yards of roadway was said to be one ton. It was put on about six weeks ago, and the centre of the roadway was certainly quite moist when he saw it yesterday. The sides of the road, where the salt had not been thrown, were comparatively dry. He had brought with him two samples of the dust—one from the centre of the roadway showing that it was still in a damp state, and the other from the sides of the roadway (within two feet of the point where the first sample was collected) showing the appearance of the dust in its dry state. So far, the experiment seemed to be quite successful in the case of Haresfield. It remained, however, to be seen whether in a deeper mine, where the air was drier, common salt of this description would have the same effect in producing dampness; and, for the purpose of showing the experience which had been already obtained in this direction, he would make a few further remarks on the subject.

In March, 1879, Professor Stokes, of the Royal Society, suggested to him the desirability of experimenting with a solution of chloride of calcium. He experimented in very dry mines in South Wales, and observed the results. He found that, contrary to his expectation and the expectation of Professor Stokes, the chloride of calcium crystallized out, and the road became quite dry where it had been sprinkled. The dryness of the mine was very much greater—as it was over 400 yards deep—than that of Haresfield Mine where the salt had been applied. A little later he saw in a French paper that a solution of chloride of calcium had been applied in the Jabin pits, where explosions had taken place. The experiment had not been successful, and the mine remained as dry as ever. In regard to watering mines he observed that Mr. Stevenson said he had very great difficulty in keeping down dust by that means. His (Mr. Galloway's) own observations had been much more satisfactory in that respect. He had had under his own superintendence extensive dry mines, where watering had been practised daily, and he found it quite possible and easy to keep down the dust. The roadways remained perfectly damp for one, or one-and-a-half days after the water had been thrown on, and only then began to dry a little. There was, as Mr. Stevenson stated, always the objection where the floor consisted of fire-clay, that it was apt to heave, and produce other difficulties; and hence it was desirable that some means of keeping down the dust should be found out which would not have this objection. If, in the course of further experiments, salt was found to attain that end, well and good; and if not, then he might mention that the same object might perhaps be attained in other ways. Salt obtained from brine pits was, according to analyses which he had seen, not quite the same as sea salt, as it contained a smaller proportion of chloride of magnesium, which he imagined was the salt that produced the slight dampness due to common salt when exposed to the atmosphere. He found, however, that the average analysis of the waters of the different oceans, given by Regnault, showed that sea water contained about 2·7 per cent. of common salt and ·8 per cent. of other salts, and nearly half of the ·8 per cent. consisted of chloride of magnesium; so that about 10 per cent. of the residual salt in sea water, remaining after the chloride of sodium had been removed by evaporation, consisted of chloride and bromide of magnesium. This chloride and bromide of magnesium were highly deliquescent; and if they could obtain those two salts without the admixture of common salt, they would have a better means of laying dust than by using common salt alone. A solution of chloride of magnesium was one of the bye products in salt making; he was not at present aware how it was disposed of, but he thought there

would be no difficulty in getting sufficient quantities of it. He suggested to the members of the Institute the propriety of making experiments with such bye products, which, no doubt, could be obtained at a much cheaper rate than common salt, and in all probability would be more efficacious in keeping down dust. Even if the dryness of the mine was so great that chloride of magnesium was unable to retain sufficient moisture to keep the roadway damp after once laying it down, dampness might to some extent be produced artificially. He observed on one occasion that it had been suggested to allow a jet of steam to pass into the air, and the same suggestion was made to him, with the same object, as an original proposition, by a gentleman in Wales, Mr. Walker Hood of Llynypia Colliery. There is one objection to allowing a jet of steam to go into the air, namely, that it would heat the current and produce a higher temperature in the workings, and this is not desirable; but he had thought that the steam might be combined with the use of water in a very finely divided state, so that the dew point of the air might be increased at the same time that the temperature was raised to only a small extent; and in that way they might perhaps produce artificially an atmosphere containing so great a degree of moisture, that either common salt or the chloride and bromide of magnesium would absorb and retain water to an extent sufficient to keep down dust. He thought an experiment of this kind could be easily and simply made by some of the members of the Institute, who had so many means at their disposal for making experiments.

Mr. John Pattinson said, he quite agreed with Mr. Galloway in the opinion that the effect which had been produced by the use of common salt in the case stated was probably owing to the presence of chloride of magnesium, and perhaps, chloride of calcium in the salt which had been used; and the effect upon the roads at Tynemouth, mentioned by the President in his able address, was no doubt also due to the same salts in the sea water used. Common salt was certainly not very deliquescent. If it was the deliquescent property of the salt which was of great advantage—and he had very little doubt that it was so—they could produce the effect more certainly by the use of chloride of magnesium or chloride of calcium. The latter substance could be more readily had, and cheaper and in larger quantities than chloride of magnesium. It happened to be one of the bye products of some of the largest chemical manufactures, and, if wanted, could be prepared in large quantities and at very little cost. He agreed with Mr. Galloway that some experiments might be usefully made with these substances. If they were found to be efficacious, he might state that many collieries, especially in this district, had already

within themselves plenty of chloride of magnesium, chloride of calcium, and also of common salt. He had the analyses of two brines which he had made, and one contained between 9,000 and 10,000 grains per gallon, and the other between 10,000 and 11,000 grains per gallon, of chlorides of sodium (common salt), calcium, and magnesium. One sample of brine contained per gallon 7,434 grains of common salt, 418 of chloride of magnesium, 2,429 of chloride of calcium, and 338 of chloride of barium. The other sample contained 6,936 grains of chloride of sodium, 1,960 of chloride of calcium, 368 of chloride of magnesium, 9 of chloride of barium, and 43 of bromide of magnesium. He might mention that chloride of barium would be much better out as it was a somewhat poisonous salt; if it was damp, however, as it no doubt would be when exposed to the atmosphere in the pit, there would be no fear of its rising up in dust. He was very much surprised to hear that in some of the collieries chloride of calcium became so dry as to crystallize out, as mentioned by Mr. Galloway.

Mr. J. T. DUNN did not know that he could add anything to what had already been said by Mr. Galloway and Mr. Pattinson. He came there prepared to suggest chloride of calcium as a substitute for salt, not knowing it had been suggested before. He agreed as to the desirability of making experiments with chloride of calcium and chloride of magnesium.

Mr. A. L. STEAVENSON said, that this suggestion came at a fortunate time, as in a short time, at Port Clarence, they would be in a position to supply salt in large quantities, and probably of good quality.

Mr. PATTINSON said, that in all probability it would be found that an admixture of common salt with chloride of calcium would be most efficacious. This could be applied either dry or in solution.

The PRESIDENT proposed a vote of thanks to Mr. Stevenson.

The following paper, by Mr. EDWIN GILPIN, on "The Gold Fields of Nova Scotia," was taken as read:—

THE GOLD FIELDS OF NOVA SCOTIA.

By EDWIN GILPIN, Jun., A.M., F.G.S., Government Inspector of Mines, Nova Scotia.

It is proposed in the following paper to lay before the members a brief account of the Gold Fields of Nova Scotia, a district of interest from a geological point of view, although as yet it has occupied but a humble rank as a gold producer.

The age of the rock masses composing this gold field is still conjectural, but the structure of the individual districts is well proved.

The commencement of a thorough geological survey promises the solution of many problems of scientific and practical importance in connection with it.

The gold fields of Nova Scotia occupy a district extending along the Atlantic Coast from Cape Canso to Yarmouth, and varying in width from ten to forty miles. The total area assigned to the auriferous strata and the rocks most intimately connected with them is estimated at from 6,500 to 7,000 square miles, of which about one-half is occupied by what are known as "granite" rocks. The shore presents a low rugged front, diversified by numerous harbours running for long distances inland, and studded with islands. The land rises gradually to a height of 560 feet, and is cut up by numerous lakes and swamps. The soil is generally poor and boulder laden, and there are large areas supporting no vegetation beyond a few shrubs. In the Lunenburg district, and many of the inland valleys there is good farming land, but generally speaking the district is valued only for its timber and gold mines.

The existence of gold in Nova Scotia was conjectured perhaps when Queen Elizabeth in 1578, in a patent granted to Sir Humphrey Gilbert, made a reservation of one-fifth of all the gold and silver he might discover. Later, in a patent issued by Charles I. to Sir William Alexander, in 1621, one-tenth of the precious metal was reserved.

The names of Bras D'or, Jeu D'or (Jeddore), etc., would seem to show that gold was not unknown among the early French settlers, and it appears on good authority that one hundred and fifty years ago, they washed from the sands of the River Avon, near Windsor, small quantities of gold.

Sir Charles Lyell, in his remarks on the "Geology of North America," published in 1842, predicted the discovery of gold in Nova Scotia.

However, public attention was not directed to the matter until the discovery of gold on the Pacific Coast caused a search to be made which was continued by returned Californian miners until 1858, when a man, drinking at a brook near Tangier, picked up a nugget of gold. From this chance discovery, and the excitement which followed, may be dated the beginning of gold mining proper in the province.

The "Granite" rocks of Nova Scotia may be divided into two sections. The western one extends from Halifax to Windsor, a distance of forty-five miles, and stretches in a great belt, interrupted by occasional patches of auriferous measures, nearly to Yarmouth. To the eastward, another band of less width stretches with several interruptions from Waverley to the Cape of Canso. These great masses are but little known and have never been mapped; the outlines given in Fig. 1, Plate XXII., are from the author's notes, and Dr. Dawson's "Acadian Geology."

Some ingenious theories have been advanced as to their being really of Laurentian age, based, it would appear, chiefly on the fact that they have in contact with them at many places bands of gneisses, mica schists, etc., which have been set down as Huronian, as they are more metamorphosed than the ordinary auriferous strata.

So far, however, as these granites have been studied in their relation to the auriferous and newer strata they serve to confirm the views entertained by Dr. Dawson, that they are intrusive masses. Near Sherbrooke, as remarked by Dr. Dawson, the quartzite at the point of junction with the granite, is slightly changed in character, having apparently minute hornblende and mica crystals developed in it, but the granite sends numerous veins into it, and in them becomes coarser in texture, and presents beautiful aggregations of plumose mica.

At Cochran's Hill auriferous measures are found lying close to one of the most persistent of the granite ranges, and are penetrated by bands of granite from one inch to six feet in thickness. The measures have exhibited a metamorphism equal to that found anywhere in the coastal range. The slates have become perfectly crystalline. Mica schists, or micaceous gneisses, with crystals of chiastolite, and staurolite, have been developed in them.

Dr. Dawson similarly describes the granite of Nictaux, as altering the Devonian beds and converting them, for a short distance away from the junction, into gneissoid rocks holding garnet. The granite sends veins into the strata, and near the junction, holds numerous angular fragments of altered slate. In the case of both the auriferous and Devonian strata, the gradual passage from gneissoid rock into the normal metamorphosed quartzite and argillite, can be frequently observed.

The Nova Scotia granite has all the characters of a plutonic rock in its want of stratification, its frequent porphyritic appearance, its passage into graphic granite, etc., and closely resembles in lithological characters the intrusive granites of the Eastern Townships of Quebec and of New England, some of which belong to the Montalban Series of Hunt, while others are later than the Upper Silurian; and it differs materially from the typical Laurentian of Canada. In the latter the gneisses are usually hornblendic, laminated, and interstratified with diorites, pyroxene rock, limestone, serpentine, etc.

These granites are evidently older than the Carboniferous, for at Horton their débris is found in the Lower Carboniferous. At Nictaux they penetrate rocks of Oriskany age. They are therefore much more recent than the auriferous strata, to which, as will be shown, a greater age must be assigned.

The pre-Carboniferous age of the gold veins is proved later on in this paper. From the relation which appears, from the map, to exist between the granites and the gold districts, it may be inferred that as the veins, as at Cochran's Hill and elsewhere, cut the granite bands, the granite intrusions and the formation of the veins are, as Dr. Dawson expresses it, "roughly contemporaneous."

Around and between these granite masses the gold bearing strata are spread, with a general strike parallel to the line of the shore, and are now presented in a series of undulations, such as would be expected from a pressure acting against the trend of the coast.

Denudation on an immense scale has swept away the crests of the anticlinals, and presented the strata in a succession of elliptical curves, the axes of which are variously inclined.

The gold bearing strata may be divided into two great sections. The upper is composed principally of black earthy pyritous slates with few beds of quartzites, and not many quartz veins. These veins are auriferous when exposed in the anticlinals similar to those in the lower section to be described further on. An instance of this auriferous character of the veins is met at Lunenburg, but it is not known at what horizon they occur. Its thickness has been estimated by Professor Hynd to be about 3,000 feet.

The lower section is composed of alternating beds of quartzites and compact sandstones, sometimes felspathic, and argillites, and is estimated to be 9,000 feet thick.

The following section, exposed in perspecting trenches at Mount Uniacke, will show the general succession of the measures in the gold

districts. It must, however, be remembered that in other districts larger lodes are found, and a much greater thickness of auriferous ground. Thus at Waverley, gold bearing lodes are known through a thickness of 3,500 feet, and at Renfrew the thickness of the known and worked gold belt is 5,000 feet.

The measurements are at right angles to the stratification, and the assays by the Connecticut State Assayist.

SECTION IN ASCENDING ORDER FROM THE AXIS OF THE ANTICLINAL MOUNT UNIACKE GOLD FIELD.

Strata.	Thickness.		Veins.		Gold Value.		
	Ft.	In.	Ft.	In.	Oz.	Dwt.	Grn.
Sandstone	15	6		2		12	7
Quartzose slate	42	0	...		...		
Slaty sandstone, with bands of slate ...	19	0	6	0	...		
Slate	1	0	...		...		
Sandstone	8	6	...		...		
Slate	1	3		2		3	0
Sandstone and slatebands	125	6	...		...		
Slate	38	6		3	...		
Quartzite	18	0	...		...		
Slate	16	0	...		...		
Quartzite	4	0	...		...		
Slate and bands of sandstone	6	0		2	...		
Sandstone and thin bands of slate	19	0		2 5 5	...		
Sandstone and band of slate	11	0	1	7		16	8
Sandstone and slate bands	8	0		7	1	2	1
Quartzose slates	13	0	...		...		
Quartzite	18	0	...		...		
Quartzite and slate bands	20	0		5	1	6	11
Sandstone and thin bands of slate	14	0	2	0		17	9
" " " "	36	0		5 8 2	...	8 7	3 3
" " " "	42	0	1	5		12	14
" " (disturbed)	29	0	...		...		
Quartzite	32	0	...		...		
Slate	12	0	3	0		5	9
Sandstones with bands of slate carrying several veins up to 8 inches	203	0	...		...		
Sandstones, grit at base passing into very fine grained massive sandstone, not auriferous	380	0	...		...		

This is succeeded by 1,630 feet of measures composed of quartzites with a few bands of slate and carrying fifteen non-auriferous veins.

THE AGE OF THE GOLD BEARING ROCKS.

It is to be regretted that as yet the age of these rocks cannot be definitely determined. There has been no systematic survey of the district, and the strata cannot be continuously followed into connection with well defined horizons further west. The following opinions are those advanced by Dr. Dawson, and they seem to the writer to be, so far as his present experience indicates, based on the only available data.

The following is his general comparative table, taken from the supplement to his "Acadian Geology:"—

CAMBRIAN.

England, etc.	Nova Scotia and New Brunswick.
Tremadoc slates and Lingula Flags.	Miré and St. Andrew's Channel Series in Cape Breton.
Menevian Series.	Acadian Series, St. John, N.B.
Longmynd Series.	Quartzites and slates of the Atlantic Coast of Nova Scotia.
Harlech grits and Llanberis slates.	

The Acadian Series of St. John, so carefully examined by Professor Hartt, forms, with its well characterised fauna, the typical representative on the Western Continent of the formation known in England as the Menevian or Barrande's Etage C. of the Primordial in Bohemia.

The Atlantic Coast Series, with the two divisions of quartzite and clay slate, so divided from the respective predominance in each of the rocks named, are considered by Dr. Dawson, Mr. Selwyn, and Professor Hynd, to precede these.

It is to be regretted that hitherto the light thrown on the subject by fossil evidence has been of the most meagre kind. Mr. Selwyn has recognised in the Lunenburg slates markings of the nature of those named in Sweden, Eophyton. Dr. Dawson, however, considers them the trails of aquatic animals named by him Rhabdichnites, which are characteristic of the Acadian Series. Professor Hynd discovered at Waverley nodular bodies and markings, which Mr. Billings referred with doubt to the genus Eospongia, and casts of Orthis. Dr. Dawson states that they may be compared with the problematical object from the Eophyton sandstone of Sweden, described by Linnarson under the name of Astylospongia radiata, but considers them fucoids with radiating fronds, allied in form to Hall's Phytopois from the Bird's Eye limestone, or to Linnarson's Scotolithus from the Eophyton sandstone, and has given them the name of Astropolithon.

The only other fossil forms observed are tubes from St. Mary's River resembling Scolithus.

So far as the above fossils give any information, they serve to confirm the supposition that the measures in question are to be referred to the Cambrian period. Within that period the fossils may be compared with those of the Fucoidal or Eophyton sandstones of Sweden, which underlie the equivalent of our Acadian series. They may therefore be regarded as probable equivalents of the Lower Cambrian or Longmynd Series of Europe.

Mention has been already made of the anticlinal folds of the auriferous measures, and their denuded summits. The veins of auriferous quartz, more particularly the subject of this paper, occur in them, and run parallel to the strata, having usually quartzite on one side and slate on the other. They follow the dips and turns of the encasing rocks, and to a casual observer appear to be really beds of quartz, formed at the same time as the beds containing them. They have, therefore, been considered by numerous writers to be true aqueous sediments.

Others again who have considered the reason of their formation, and the characteristics of the deposits, affirm with great show of reason that they are true veins.

Imagine these alternating layers of slate and quartzite ridged up under the influence of a pressure acting in a horizontal direction, and possibly to some extent confined by the more unyielding granite masses, it will be readily conceived that, at points of least resistance, which would be the crests and sides of the flexures, the strata would separate most readily at the junction of beds of differing toughness, leaving fissures closely following the outlines of the undulations. Denudation has swept away the crests of these anticlinals, and now presents these concentric fissures filled with quartz, as shown on the plan of the Waverley district. (Plate XXIII.)

A different effect, however, is noticed when the ends of the anticlinals are penetrated. Here the pressure acting on the layers not capable of escaping the pressure by flexure as readily as those already described, has caused the beds to form corrugations, accompanied, doubtless, in many cases by a slight movement of one bed on another. The larger of these corrugations, when filled with quartz, present the appearance of logs of wood laid side by side and connected by threads of the same mineral, and are called "barrel quartz."

In Plate XXIV. is given a sketch of one of these corrugated lodes, worked last year at Moose river. The lode varied in thickness from ¾ of an inch to 4 inches, and presented the apex of an anticlinal dipping to

the east. The lode was accompanied by a similar one a few inches below it. Both lodes carried gold, iron, and lead sulphides, and a little calcite, and gold showed through the intervening slates. The corrugations in the slates were parallel to those of the lodes, and extended as far as a section was exposed by the excavations. Similar, but less strongly marked, corrugations occur in many of the straight running lodes, and in some instances their transverse axes point to the line of pressure.

Other effects are recognisable as caused by this pressure. Thus veins called "anglers" are observed breaking abruptly across the quartzites, and obliquely across the slate beds, and in some instances proving rich sometimes in one rock and sometimes in the other (see Plate XXV.) Numerous feeders, sometimes auriferous, radiate from the lodes into the surrounding beds, and in some cases connect them. The thin layers of slate found in most instances on one side of the lode are frequently so soft and broken as to be readily removed by the miner's pick. The wider beds of slate are frequently penetrated by several irregular veins, sometimes uniting and again diverging, and the whole mass is filled with a net work of spurs and threads of quartz.

These fissures were filled presumably by the deposition of the quartz and associated minerals from aqueous or other solutions, in a manner similar to that in which Mr. J. A. Phillips described the formation of the auriferous quartz veins of California. There have been certain facts observed in connection with the auriferous values of the lodes in this province which may be worthy of mention.

It is found that, as a rule, in wide bands of slate the veins are feebly auriferous, as is also the case in massive sandstones, or in sections composed principally of quartzites. The most productive veins are found where bands of quartzite and slate of moderate thickness alternate. This may possibly be due to the slates being readily penetrated by solutions owing to their original lamination, and its increase by the pressure alluded to above, and to the fact that the original deposition of the gold may have been dependent on this alternation of beds of differing minerals.

These remarks apply to the lower section of the auriferous measures. The overlying slates, although pyritous and containing numerous quartz lodes, undistinguishable from those already considered, have not yet yielded any containing enough free gold to warrant working by the present systems of milling.

The worked veins vary in thickness from one half-an-inch to six feet. The usual width being from 4 to 8 inches, and a 20-inch vein is considered a large one. Their length varies from a few hundred feet to over two

miles. They show frequently a banded structure with cavities filled with quartz and calcite crystals. Other veins show a compact oily quartz, or are slightly granular, and break most readily across the vein. Pieces of slate constantly occur in them, and there are also "horses." The fissures have been seen to extend after the quartz filling them has run out.

The undulations of the auriferous strata were subsequently disturbed by numerous faults. From the map of the Waverley gold field, it will be seen that it is disturbed by two heavy faults, running north and south, and throwing the measures 180 to 570 feet. Numerous small faults are met, and they are found, as a rule, to belong to either of two sets of faults, the one having a north and south and the other an east and west course.

These heavy faults seldom hold veins, but there have been disturbances, subsequent to the filling of the veins, which have produced fissures also holding veins, sometimes themselves auriferous, and generally influencing the gold values of the veins they intersect or touch.

An instance of this is shown at Mount Uniacke, where the Nugget Lode (Plate XXVI., Fig. 1), which has been traced for about 2,500 feet, has, in the main openings a "bull" lode lying on one side of it, and touching it at intervals of several feet. The thickness of the "bull" lode is from 3 to 6 inches, and it consists of hard white quartz holding little gold and few minerals, except where the nugget lode runs against it and pinches, when it carries gold enough to warrant its being crushed. The true lode is from 3 to 8 inches thick, composed of dark-coloured quartz, and carries much iron and arsenical pyrites. The foot wall is a dark laminated slate, succeeded by a slaty quartzite. This lode has yielded profitable returns to a depth of 200 feet, when it was abandoned as it had got too deep for a horse to raise the ore. Another of these later lodes is shown at the Belt Mine, Montagu (Plate XXVI., Fig. 2), where the cross lode made the vein very rich at the point of intersection. In every district large barren white quartz lodes are met, which have been considered to be a result of these later disturbances.

There seems to be but one true igneous dyke cutting the gold measures. This occurs at Strawberry Hill, Tangier, and is about 40 feet wide, and runs at right angles to the measures, cutting the veins without, to any appreciable extent, influencing their positions or metallic contents. Bedded diorite dykes are met in the Lunenburg district.

The period at which the veins were filled cannot be precisely ascertained. From its occurrence in the lower carboniferous conglomerate, to be referred to, it would appear that the greater part had been deposited previous to that era. The date of the subsequent faults and of the filling

by quartz, etc., of the fissures they formed is not clear. There are no measures in the Province of a date later than the Triassic sandstones of Truro, and it is not known if they are faulted by the extensions of the sets of dislocations in the gold fields which have been described.

It is known that the strata succeeding the carboniferous limestones up to a period as late at the Upper or Permo carboniferous are intersected by sets of faults corresponding to those of the gold districts. It may, therefore, be conjectured that the filling of the second set of fissures was not earlier than the latest period to which can be referred these systems of faults.

The minerals usually associated with the gold are sulphides and arsenides of iron, galena, blende, copper pyrites, oxide of iron, copper glance, molybdenite, native copper, sulphur, chlorite, felspar, garnet, mica, calcite, felsite, etc., not, however, in quantities of economic importance. The presence of these minerals, especially of the sulphides and arsenides of iron, appears to be essential to the value of the lodes. It is true that numbers of lodes have been worked causing but trifling quantities of pyrites, etc.; but if not present in the vein they are found in the enclosing walls, which, in this case are sometimes rich enough to warrant crushing.

The gold occurs chiefly as free or coarse gold in grains visible to the naked eye, and in strings or filaments between the planes of the quartz. A considerable quantity is enclosed in the nodules and nests of the associated minerals, as will be noticed further on. Crystals have occasionally been found not exceeding one-third of an inch in diameter. One from Tangier was a rhombic dodecahedron with bevelled edges, and brilliant finely striated faces. Others are octahedra, sometimes elongated and flattened, with dull and rounded faces.

The distribution of the gold in the veins is to a certain extent capricious. Few lodes carry a uniform yield over a space exceeding 500 feet. There is in almost every vein one or more zones or "pay streaks" of quartz much richer than that surrounding it. These zones do not appear to be the effect of any law that has yet been applied to our mines. They lie at every angle, and appear to be of very varied length and width.

At the Wellington mine in Sherbrooke, one of these streaks has been followed nearly 600 feet from the surface without showing signs of exhaustion. The surrounding quartz varied from 2 to 6 dwts. to the ton, while the "pay streak" ran as high as 20 ounces.

Plate XXVII. shows this distribution of the gold, from a record kept for three years of the yield of each parcel of quartz, at the Lawson mine in the Belt lode, Montagu.

The richest part of the lode at the surface was at the main shaft, and it dipped to the westward. Finally the vein was found to thin out to 1½ inches to the eastward, and was worked to the western boundary of the property where it was 6 inches thick. The effect of a cross lode, shown in the section, Plate XXVII., Fig. 2, was to greatly enrich the main lode, some lots of quartz from a point below its intersection yielding 40 ounces to the ton. The greatest depth reached was 300 feet, and it was abandoned as soon as the "pay streak" showed signs of lessened value, without any attempt being made to prove its extension. During the five years it was worked by the last proprietor, about 200,000 dollars* worth of gold was taken out, which yielded a handsome return over and above all working expenses.

Another parallel "pay streak" was worked in the same lode, a few hundred feet away, on an adjoining property.

The following brief description of the Waverley gold district will answer for the rest as they present no distinctive features. It is condensed from a report and survey, made a few years ago for the Provincial Government, by Mr. H. Y. Hynd.

The measures as shown on the plan, Plate XXIII., were originally thrown into an immense fold the base or east end of which rests on the "granitic" series, while the western production can be traced for several miles. Subsequent faults have shifted the axis to the north, and the eastern fault has made a subordinate anticlinal by bringing up lower beds. It was in this eastern section that the "barrel" quartz was first met.

In some districts the undulation has become an overlap, thus at Tangier and Wine Harbour, some of the lodes when exposed have a dip to the north at their crop, on following them downward they reverse and dip to the south.

The lowest bed met in the Waverley district is a thin bed of slate, of a greenish and grey colour, lying 24 feet below the "barrel" quartz. In the better known part of the Waverley series are met massive beds of quartzite, sandstones, etc., interstratified with thin beds of clay slates.

The following is a general section in ascending order:—

1.—*Barrel quartz group.*—Comprising 120 feet of quartzite with slate belts and holding four lodes.

2.—*Rose group.*—Containing three lodes, and comprising 60 feet of quartzite with greenish gray and bluish slates, with numerous minute crystals of iron pyrites.

* The English pound being equal to 4·87 dollars.

3.—*Taylor group.*—This group is characterised by a bed of concretionary quartzite, 70 feet thick, already referred to as fossilferous, and by thin bands of curly and finely laminated plumbaginous slates of brilliant metallic lustre. It contains no fewer than 27 lodes, the thickest of which averages 18 inches; and has a total thickness of 320 feet.

4.—*Tudor group.*—Characterised by two massive beds of gray quartzite holding large crystals and nodules of mispickel, and pebbles of slate. Its thickness is 190 feet, and it holds 3 lodes.

5.—*The south lode group.*—This group is 600 feet thick and holds numerous lodes not yet worked to any extent.

The lodes in Waverley have been in some instances extensively and successfully worked. One or two have been traced around the anticlinal axis, but as might be expected the identification of individual lodes on reverse dips can be accomplished only by means of the accompanying beds as their small size and great number render mineral characters and physical properties an unsafe guide.

ALLUVIAL GOLD.

As yet alluvial gold has not been worked in this Province to any noteworthy extent, the total yield being estimated at about 4,000 ounces. The geologist at once marks the traces of severe and prolonged ice action in the Nova Scotia gold districts. The markings of the striæ are from S. 20′ W. to S. 28° E. magnetic, nearly at right angles to the general course of the strata, and the edges of the harder beds are presented in long rounded ridges.

There appears to have been two periods of attrition and transportation. The effects of the earlier one are now visible in immense "boars backs" from 50 to 150 feet in height, and sometimes a mile in length, following a general north and south course. These may be seen on the road from Halifax to Montagu, at Musquodoboit, Tangier, etc. They hold immense boulders of granite and quartzite, fragments of slate and quartz imbedded in clay, sometimes with layers of sand and gravel. The nearest localities furnishing the granite are from two to six miles to the north. In some cases the original site of the enclosed rocks must be sought for at much greater distances. For example, at Halifax, the drift contains fragments of amygdaloidal trap, identical in appearance with that found *in situ* at Blomidon, on the Bay of Fundy, fifty miles away.

A second and more local action is also visible, and by its agency the auriferous veins are usually found. This action has carried the quartzite

and slate boulders from 100 to 1,800 feet on a course corresponding very closely with that of the striæ. Thus "prospectors" finding auriferous quartz boulders, costean to the north and frequently trace the boulders to lodes corresponding in every respect to the boulders first found. As an instance it may be mentioned that at Montagu the Rose lode, so called from the red colour of its quartz, was found by tracing the boulders through the drift on the line of the striæ for a distance of 1,200 feet.

In consequence of this limited transportation the surface covering of many of the gold districts is auriferous enough to work. So local is this drift that in several districts numbers of men have made a living by breaking up and amalgamating the quartz boulders in hand mortars, when a few yards away a day's search would not afford the smallest "sight" of gold.

The writer is not prepared to account for the limited distance to which these boulders have been carried, except it be by the action of ice on a coast line gradually changing its level, and he does not anticipate that, in Nova Scotia, discoveries will be made of alluvial deposits as extensive as those of Australia and California, owing to the proximity of the gold districts to the ocean, and their comparatively low average elevation (200 feet) above the sea level. Still the limited explorations that have been made in the bottoms of the innumerable lakes which occur all through the coast section, and from still waters in the various rivers, have shown that they are frequently auriferous. The expense of drainage has deterred attempts to test them, but some adaptation of the vacuum or steam dredges lately introduced in the United States may enable this to be done at a cheap rate.

At Gays River is presented an ancient auriferous alluvium in a lower carboniferous conglomerate, similar to that described in the writer's paper on the Gypsum of Nova Scotia* as characterising the base of the carboniferous formation at many points in the province. Here the conglomerate resting on the upturned edges of the auriferous slates, carries considerable amounts of gold near the junction, and the crevices of the slate frequently carry the same metal embedded in clay and oxide of iron. The deposit appears to form part of an ancient river bed, and was worked for some time by drifts driven on the slate, and a sort of long-wall work taking out the conglomerate as high as it showed gold.

At Lunenburg the beach, open to the Atlantic, was found for several hundred yards to be highly auriferous, and considerable quantities of gold

* Vol. XXX., page 53.

were washed out from the sand, but, as may be imagined, operations could not be carried on long. The measures at this point belong to the series of slates forming the upper division of the auriferous strata. They are penetrated by numerous veins showing gold, but the attempts made to work them did not prove profitable. It has been conjectured that this deposit of gold was accumulated by the disintegration of carboniferous conglomerates similar to those of Gays River, as considerable patches of lower carboniferous measures are known to occupy the shores of Chester Basin, remnants of some great carboniferous continent formerly extending where the Atlantic now reigns.

Having thus briefly noticed the chief points of geological interest connected with the gold fields, the part the miner has played in the working of the treasures spread out before him alone remains to be referred to. This may be divided under the two heads of Mining and Milling.

MINING.

In the earlier operations many companies were started with schemes too ambitious for their means and broke down before they could get into working order. Others paid large dividends for a few years, but having no reserve funds abandoned the work when they encountered the trial of poor ore, which must be faced by every miner sooner or later. Other properties again have been continuously worked and have made handsome returns.

On the failure of many of the large companies their properties were sublet to tributers, some of whom have done well by systematic mining, and others have effected little beyond robbing the richer parts of the lodes within a few yards of the surface.

During the past two years a number of the more promising properties have been purchased by American capitalists, and it is expected that their mining experience gathered in the Western States will lead to a much larger output than has been obtained for some years past.

When it is determined to work a vein, a main shaft is sunk, at first to a depth of about 60 feet, and a shaft on each side from 50 to 150 feet from the central one. At a depth of 40 feet these shafts are connected by levels, and stoping started from six points and continued in some cases to the surface. Then commencing 15 or 20 feet below the levels, a breast of two or more underhand stopes is carried from shaft to shaft. Frequently, when it is not desired to work to any depth, shafts are sunk at close intervals, and the rock raised through several of them. All these shafts are sunk on the vein so that they vary from perpendicular sinkings to slopes at various angles, as low as 45 degrees.

This work is continued as long as the quartz pays, and some of the mines have reached a depth of 600 feet. Usually in the more systematically worked mines each stope has the following scaffold low enough to permit of convenient stowage.

Formerly it was customary to take out at one operation the lode and enough of the slate, etc., to allow working room of from 2 to 3 feet. This was found to lead to serious loss of gold, both by theft and by mixture of the quartz with the rock, which had nearly all to be sorted at bank. Now the slate, etc., on one side of the vein is first taken out, and the vein allowed to stand untouched until several hundred square feet of it are exposed. Then it is removed at one operation and sent directly to the surface. This method costs rather more, as the width of the ground removed is increased by the thickness of the lode, but the quartz is not so much exposed to the workmen, and very little of it is lost.

As might be expected from the nature of the strata, the mines are as a rule very free from water. It may be said that at a depth of 300 feet they are perfectly dry whenever proper care has been taken to puddle the shafts on the rock bed, and not to carry the stopes too near the surface.

The most noticeable exception to this rule that has come under the writer's notice occurred recently at the Rose Mine, Montagu, where at 150 feet the main shaft struck a flat throw to the south of three feet. This throw evidently came to the surface under an adjacent swamp, and passed the water so rapidly that the men had to immediately leave their work, which was not resumed until more powerful pumps had been set up.

The pumps used are of every variety, from Cornish patterns to steam ejectors.

The explosive used is chiefly powder, but in many of the lodes having narrow slate bands, or very tightly bound, dynamite is used. Formerly English dynamite and powder were exclusively used, but local factories now supply both these requisites at fair rates and of good quality.

The drilling is entirely two-handed, and the system of single-hand drills never succeeded in establishing itself here. Machine drills are but little used, and the narrow inclined workings, which necessarily characterise our gold mines, almost forbid their application except for driving levels, etc. They will, however, be found economical when attention is turned to working the broad belts of banded slate and quartzite, which are met in many of the districts, and offer an abundant supply of low grade ores.

The cost of extracting a ton of ore varies between wide limits. In the narrower veins it frequently costs as high as 15·00 dollars per ton of 2,000 lbs., while in veins three feet wide and upwards it is raised for

1·50 dollars a ton, and in slate bands from three to ten feet wide the cost has been known not to exceed ·95 cents. The wages of miners being 1·25 dollars, and of labourers 90 cents to a dollar a day.

MILLING.

The quartzite from the mine is passed directly to the stamp mill. At the commencement of gold mining here attempts were made to roast the ores before they were stamped, but as the ordinary circular open kilns were used with wood for fuel, the heat was not more than sufficient to drive off part of the sulphur in combination with the iron, and to coat the free gold with arsenic from the almost omnipresent mispickel, and they were abandoned.

The following description, and the Plate XXVIII., for which the writer is indebted to Messrs. J. F. Torrance and L. W. Scaife, of the Pittsburgh Gold Mining Co., showing one of the best mills in the Province, will give an idea of the general principles on which the quartz is treated.

A "battery" consists of an oblong cast iron box, *a*, containing four or five stamps placed at regular intervals, and large enough to allow a space of several inches between the stamps and the sides of the box. The stamps *b* and the stems are of iron, and weigh from 450 to 750 lbs., the stems *c* pass through vertical guides *d d*, and are provided with tappits *f*. A shaft fitted with four or five double cams *e e*, lifts these stamps from six to nine inches, and the quartz in the box is crushed by their unaided fall. Two or more batteries are frequently driven from the same shaft. Apertures *j* are provided for introducing the quartz and water into the boxes, and gratings *h* allow of its escape when crushed to the desired fineness. The crushed quartz is passed over copper plates amalgamated with mercury, and subjected to other contrivances for extracting the gold.

The mill was made by Fraser and Chalmers, Chicago, and the total weight (including no wood, except the guides and props) is 29,450 lbs. Each of the two "batteries" contains five stamps, and weighs 5,500 lbs. Each stamp has a maximum weight of 750 lbs., and falls for each blow about 9 inches. The mill was designed to run at the rate of from 85 to 90 drops for each stamp per minute, crushing 20 tons of quartz in 24 hours, but owing to the fact that copper amalgamated plates are placed in the batteries to catch the gold, it does not generally exceed a speed of 50 drops per minute, crushing about 15 tons in 24 hours to the finest perforated plate. Each "battery" contains front and back copper plates, and outside the gratings are reversing and splash plates, and the usual long copper plate, about three feet in length, all amalgamated with mercury.

Finally there is a mercury trap, for arresting any mercury or amalgam that is not caught by the plates, which consists of a pyramidal box base upwards, into which the battery tailings fall as they leave the plates. A stream of fresh water enters the apex and forms a sort of quicksand in the box, wherein the mercury is caught and gradually settles to the bottom whence it is drawn off. The tailings then pass over troughs lined with blankets which retain the pyrites, which are washed out by hand into a tub of water at regular intervals.

The quartz is hauled into the mill, weighed, and thrown on an iron grating with openings two inches square, which allows the fine stuff to fall into a bin, capable of holding about seven tons. The coarse quartz is drawn by hand to the mouth of a Phelps' breaker also discharging into bins. From them the quartz passes by means of self-feeders of simple construction into the batteries.

The motive power is furnished by a thirty inch Leffell turbine, the fall of water being twenty-one feet, which would allow of the mill being enlarged to double its present capacity.

The fineness to which the quartz is crushed varies in different mills, from a size passing through a mesh of 150 holes to the square inch, down to one of 400 holes.

The following estimate of the cost of crushing is from actual performance, and a mill of ten stamps driven by steam power which is also utilised for driving a small pump :—

QUARTZ CRUSHED TO PASS THROUGH FINEST TWILLED WIRE CLOTH.

	Dollars.
Wood 2¼ cords at ·75 dollar	1·57
One man by day, to fire and feed batteries at	1·50
One man by night at	1·50
One man by night at	1·25
Chemicals and oil	·50
Wear and tear	·75
Total	7·07
Quartz crushed in 24 hours, 8 tons.	
Cost per ton	·88⅜

The above is for quartz alone; when, as is frequently the case, slate is crushed with the quartz the cost per ton would be materially reduced. At the Ophir Mill, at Renfrew, some years ago, the cost per ton for quartz was 60 cents, when crushing at the rate of 600 tons per month.

In some mills the use of plates in the "batteries" is not adopted, but mercury is added at regular intervals to the ore undergoing pulverisation; the resulting amalgam accumulates around the circular dies on which the stamps fall, and is taken out at the week end. The use of mercury traps and blankets is not as general as it might be. As the gold is generally coarse much of it is retained in the batteries, and the loss is in the fine gold not caught by the plates. Excluding the gold found in a state of minute subdivision in the sulphurets, the mills as a rule do not extract over 75 per cent. of the gold.

The causes of this are the casing of the gold by grease from lamps, dynamite, etc., and the powdered silicates of alumina which form an unctuous slime, as well as the vibratory motion of the stamps inducing a crystalline condition of the gold unfavourable to amalgamation, in addition to the flouring of the gold by the stamping, so that it floats too rapidly over the plates to permit of its being caught by the mercury. No process has yet been found equal to the task of recovering the gold thus lost.

As already stated, considerable quantities of arsenical pyrites and sulphurets of iron, lead, and copper are found in the veins usually in close connection with the gold. The percentage present of these minerals varies very much. Some veins and the encasing rocks are heavily loaded with them up to a proportion as high as 60 per cent.; while in other veins, equally auriferous, the quantity will not exceed one per cent. The average amount may be estimated at not less than 5 per cent.

They are presented as scattered crystals, as films in the bands of the veins, and as irregular masses or pockets frequently connected by threads.

As an almost universal rule they contain gold. A marked exception has been noted at Mount Uniacke where a number of small veins containing large amounts of mispickel yielded but mere traces of gold and silver. Beautiful specimens of gold are frequently secured by treating nodules of pyrites with acid, which presents the metal in curiously interlaced plates and films, when by a previous examination no gold could be detected. As yet the treatment of these pyrites has been of the most superficial character, they are passed through the mills together with the quartz and allowed to run away with the tailings.

The following assays of these ores, freed from quartz, will show their value:—

Locality.	Area.	Ore.	Yield per Ton of 2,000 Lbs.	
			Gold.	Silver.
			Oz. Dwt. Gr.	Oz. Dwt. Gr.
Wine Harbour...	Provincial Co....	Arsenical pyrites ...	11 8 16	...
Sherbrooke ...	Boulder Area ...	Arsenical pyrites and galena	4 1 16	8 19 10
Do. ...	Coburg Area ...	Arsenical pyrites ...	1 12 15	6 10 16
Do. ...	Canada Co. ...	Mispickel and iron pyrites	45 0 0	...
Do. ...	Meridian Co. ...	Mispickel and iron pyrites	1 12 16	9 0 0
Montagu ...	O'Connor Area...	Mispickel and iron pyrites	12 12 22	1 0 0
Do. ...	Belt Lode ...	Mispickel	100 0 0	...
Ovens	McCullochlot ...	Mispickel and iron pyrites	242 16 0	16 5 0

These results are confirmed by the assays of the same ores from various districts made by the writer, who on several occasions, has found nickel and cobalt present up to 2 per cent. The following assays of pyrites which have been concentrated from tailings, show the inadequacy of the ordinary process of stamping to extract the gold from them.

District.	Area of Vein.	Ore.	Yield per Ton of 2,000 Lbs.	
			Gold.	Silver.
			Oz. Dwt. Gr.	Oz. Dwt. Gr.
Tangier ...	New York Co.	Concent. arsen. and sulphides	6 5 0	2 4 0
Do. ...	Leary Lode ..	Do. do. do.	4 14 4	...
Waverley ...	...	Do. do. do.	6 14 1	0 10 0
Sherbrooke ..	Average lots..	Do. do. do.	2 10 0	...

The following table shows the assay values of several samples of tailings and pyrites taken from waste heaps not concentrated, showing that much free gold is lost in addition to that carried away by the various pyrites, as already alluded to.

District.	Area.	Ore.	Yield per Ton of 2,000 Lbs. Gold. Oz. Dwt. Gr.	Silver. Oz. Dwt. Gr.
Waverley ...	...	Tailings	0 oz. 7 dwt. 4 gr.	
Do. ...	Barrel quartz	Do.	15 0	...
Montagu ...	Belt mill ...	Do.	16 13	...
Do. ...	...	Tailings natural concentration	3 0 0	...

It would seem that no regular system of assays of the values of the ore and pyrites before and after milling has ever been carried out here. A few such experiments would afford valuable data to replace the empirical and haphazard method of heating the ores too frequently seen among our miners.

At Montagu a Frome concentrator has been erected to heat the tailings of that district, which are said to yield pyrites averaging 60 dollars to the ton. It is yet too soon to speak of its practical working, but should it equal the expectations of the builder there is a good field for this work, as about 412,700 tons have been crushed since gold mining began here.

The amalgam of gold and mercury is squeezed in canvas and leather bags to get rid of as much mercury as possible, and heated in a crucible, having a close lid fitted with condensing appliances. The resulting gold sponge is smelted with oxidising re-agents, poured into oblong moulds and forwarded to the United States, where it is sold on the Mint assays.

Nova Scotia gold, like that of other countries, is an alloy of which silver forms the chief impurity. As a rule it is of a high degree of fineness. The following analyses were made some years ago, but represent its character at the present time:—

Locality.	Authority.	Composition. Gold.	Silver.	Iron.	Copper	Lead.	Zinc.	Total.
Mooseland	O. C. Marsh ...	98·13	1·76	trace	·05	...	...	99·94
Tangier Field Lode.	B. Silliman ...	97·25	2·75	...	...	...	...	100·00
Do. Leary do.	U. S. Assay Office ..	96·60	...	...	...	...	...	...
Waverley	H. How	94·69	4·74	...	·39	...	·16	99·98
Ovens	A. Gesner	93·06	6·60	...	·09	...	...	99·75

This fineness is much influenced by the presence of galena, as the gold from certain lodes carrying large quantities of this mineral sometimes runs as low as 800 parts in 1,000. From numerous assays the average fineness of gold from different countries is about:—

	Parts in 1,000.
Victoria	958
Nova Scotia	955
California	880
Russia	891
British Columbia	875

The foregoing remarks touch briefly on the chief points of interest to the geologist and miner presented by the Nova Scotia gold fields, and it is feared that clearness of detail has to some extent been sacrificed to a fear of trespassing on the patience of the members.

Doubtless the chief attention of the miners here, who, as a rule, possess little capital, will continue to be directed to the small rich veins yielding quick returns, and it is to be regretted that as a rule their operations are confined to working out the more accessible parts of the pay streaks, and no systematic scheme of work is attempted. It is anticipated, however, that in the future the greatest reliance will be placed on the low grade ores. There are numerous belts known to contain many thousands of tons of quartz and slate, yielding by mill tests up to seven pennyweights (6·70 dollars) of gold to the ton. From the costs of extraction and milling already given it will be seen that in many cases these ores would yield good returns if worked on a fairly large and careful system. This experiment is now being practically tested in the Sherbrooke district by parties who purpose adopting the usual treatment in stamp mills to secure the coarse gold, and a systematic concentration of the tailings which will yield considerable quantities of arsenical and other pyrites. These would find a ready sale at the reduction works of the Eastern States, and form an important item in the returns.

The gold is held by the Provincial Government who grant areas of 250 by 150 feet for a term of twenty-one years, with option of renewal, for a fee of two dollars, and a royalty of two per cent. on the gross value of the smelted gold produced, which is valued at nineteen dollars an ounce (from 20 to 60 cents less than its market value). The royalty is collected from the mill owners, who are obliged to give bonds, and make sworn returns of the quartz crushed and the yield of gold.

The following tables show the total yield of gold since 1862, in which year systematic statistics were first collected.

NOVA SCOTIA GOLD FIELDS.—GENERAL ANNUAL SUMMARY.

Year.	Total Ounces of Gold Extracted.				Stuff Crushed.	Yield per Ton of 2,000 Lbs.			Total Days Labour.	Average Earnings per Man per Day and Year of 300 days at 18 dollars per Oz.	
	Oz.	Dwt.	Gr.		Tons.	Oz.	Dwt.	Gr.		Dollars.	Dollars.
1862	7,275	0	0		6,473	1	2	11	156,000	83	249
1863	14,001	14	17		17,002		16	11	273,624	92	276
1864	20,022	18	13		21,434		18	16	252,720	1·42	426
1865	25,454	4	8		24,423	1	0	20	212,966	2·15	645
1866	25,204	13	2		32,161		15	2	211,796	2·14	642
1867	27,314	11	11		31,386		17	9	218,894	2·24	672
1868	20,541	6	10		32,262		12	17	241,462	1·53	459
1869	17,868	0	19		35,147		10	4	210,938	1·52	456
1870	19,866	5	5		30,829		12	21	173,680	2·05	615
1871	19.227	7	4		30,791		12	11	162,994	2·12	636
1872	13,094	17	6		17,093		15	7	112,476	2·09	627
1873	11,852	7	19		17,708		13	9	93,470	2·28	684
1874	9.140	13	9		13,844		13	5	77,246	2·12	636
1875	11,208	14	19		14,810		15	4	91,698	2·20	660
1876	12,038	13	18		15,490		15	13	111,304	1·94	582
1877	16,882	6	1		17,369		19	10	123,565	2·46	738
1878	12,577	1	22		17,990		13	23	110,422	2·05	615
1879	13,801	8	10		15,936		17	8	92,002	2·34	702
1880	13,234	0	4		14,037		18	20	103,826	2·18	654
1881	10,756	13	2		16,556		12	20	126,308	1·52	456
Total	321,362	18	7		422,741	.....			3,157,391	...	...

It is computed that about 8,000 ounces were produced before that date, which would make the total amount to the present date about 330,000 ounces.

In addition to the amount legitimately mined and crushed, there is reason to believe that in every district a very considerable quantity is stolen by the miners, theft being assisted by the common occurrence of the gold in small nuggets or "sights" in the quartz. Much of the richest quartz from numerous veins worked by two or three men is known to be reduced in hand mortars, and the resulting gold is surreptitiously sold, so that the returns made to the Department of Mines may be considered as by no means fully representing the amount of gold extracted.

The tables also show the number of mills, which it may be remarked work only at intervals, also the number of days' labour performed at mining, prospecting, and surface work, from which it will appear that the business although small is fairly remunerative.

NOVA SCOTIA GOLD FIELDS.—GENERAL STATEMENT FOR THE YEAR 1881.

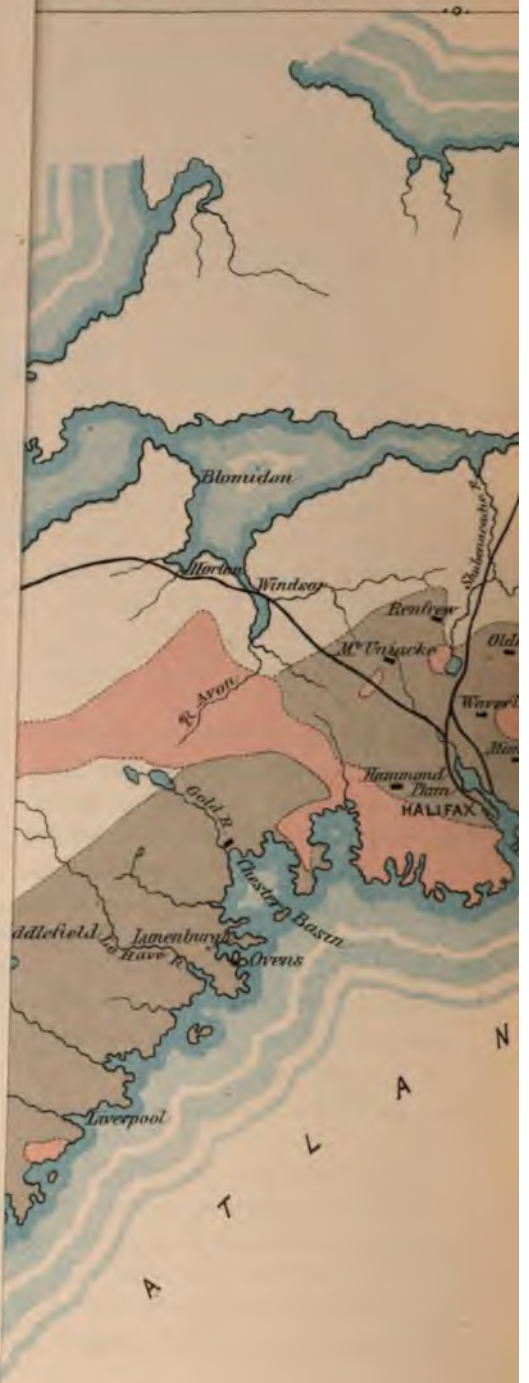
Districts.	Number of Mines.	Days' Labour.	Mills Employed.	Steam Mills.	Water Mills.	Quartz, etc., Crushed.	Yield per Ton.	Maximum Yield per Ton.	Total Yield of Gold.	Average Yield per Man per Day for 12 Months at 18 dollars per Oz.
							Oz. Dwt. Gr.	Oz. Dwt. Gr.	Oz. Dwt. Gr.	Dollars.
Carribon ...	3	15,426	3	2	1	1,661	13 14	6 3 16	1,129 18 13	1·31
Gays River ...	1	274	...	...	...	...	...	...	12 14 7	·78
Montagu ...	2	17,982	2	2	...	1,165	15 10	3 1 15	900 6 16	·90
Oldham ...	1	2,471	2	1	1	604	10 21	1 7 9	329 10 4	·98
Renfrew ...	2	5,038	1	...	1	583	9 5	1 5 19	269 8 13	·96
Stormont ...	1	4,332	...	...	...	80	9 18	5 3 0	173 10 0	1·58
Tangier ...	3	11,721	3	1	2	716	2 3 9	2 3 9	399 9 16	·73
Uniacke ...	3	10,003	4	3	1	3,094	11 3	2 5 7	1,355 8 21	·61
Waverley ...	2	5,517	3	1	2	535	8 23	2 0 0	374 0 0	2·28
Sherbrooke ...	10	29,285	6	4	2	5,279	14 0	1 18 6	2,580 2 20	1·32
Wine Harbor	1	5,098	1	...	1	552	1 8 20	3 3 0	795 14 0	2·80
Unproclaimed..	4	19,161	5	1	4	2,287	1 1 7	2 11 9	2,436 9 12	2·20
	33	126,308	30	15	15	16,556	12 20	6 3 16	10,756 13 2	1·52

From the foregoing remarks it will be seen that the area containing gold is very large, and that the little work that has hitherto been performed has shown that there are numerous lodes that have yielded good returns. The district as yet has not shown the extensive alluvial deposits characterising those countries which have become famous for their production of gold, and the future development will, so far as can be judged at present, be due to more extensive working of the veins.

The district affords good openings for men having capital and mining experience, and as a rule such men have done well here. Companies have done equally well whenever their operations have been controlled by competent agents, who have learned to work on the systems experience has shown to be best adapted to the country, and have not maintained the rules of mining learned in wide lodes, etc.

When the cheapness of labour, the abundance of water power, a favourable climate, and the accessibility of the district are considered, it may be fairly anticipated that gradually the attention of miners and capitalists will be turned to the Nova Scotia gold fields, and that with improved methods of treatment, and the accumulation of experience in detecting and following the richer deposits this industry will become a leading one in the province.

strate Mr Edwin Gilpin's paper "On



Fields of Nova Scotia.

SKETCH MAP,

NOVA SCOTIA GOLD FIELDS.

Granitic and Gneissic rocks.
Auriferous Quartzites and Slates.
Gold Mines.

Based on Dr Dawson's Map, Acadian Geology, 2nd Edition.

To illustrate Mr. Edwin Gilpin's paper "On the Gold Fields of Nova Scotia."

FIG. 3.

SKETCH OF CORRUGATED LODE,

Moose River,

a, Soft slates – b, Lode ¾" to 4" thick,

c, Arenuceous slate,

To illustrate Mr. Edwin Gilpin's paper "On the Gold Fields of Nova Scotia."

Fig. 3.

SKETCH OF CORRUGATED LODE,

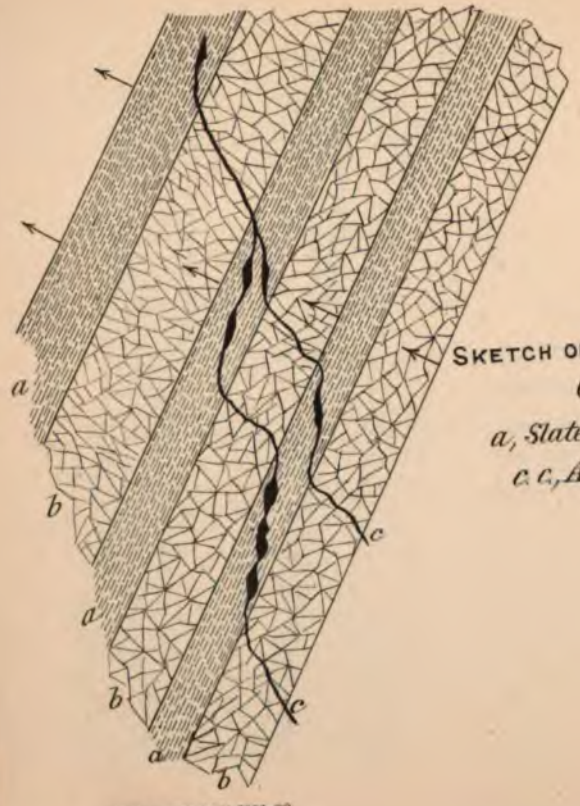
Moose River;

a, Soft slates – b, Lode ¾" to 4" thick;

c, Arenaceous slate,

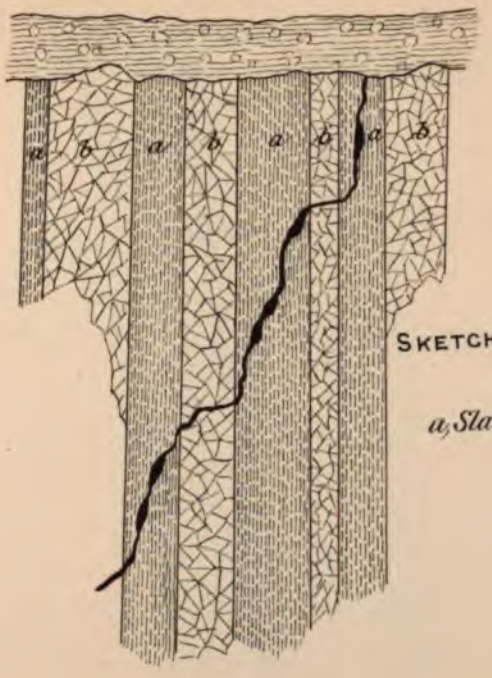
To illustrate Mr Edwin Gilpin's paper "On the Gold Fields of Nova Scotia".

FIG. 1.



SKETCH OF "ANGLING" LODE,
Oldham,
a, Slate. — b, Quartzite,
c c, Angling lodes.

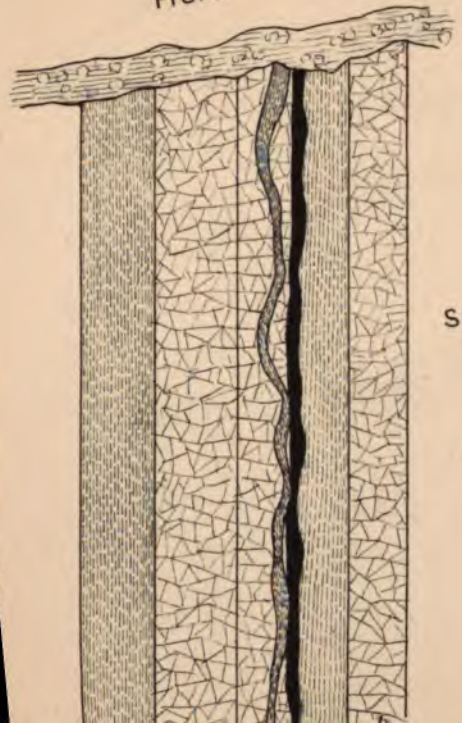
FIG. 2.



SKETCH OF "ANGLING" LODE,
Oldham.
a, Slate. — b, Quartzite.

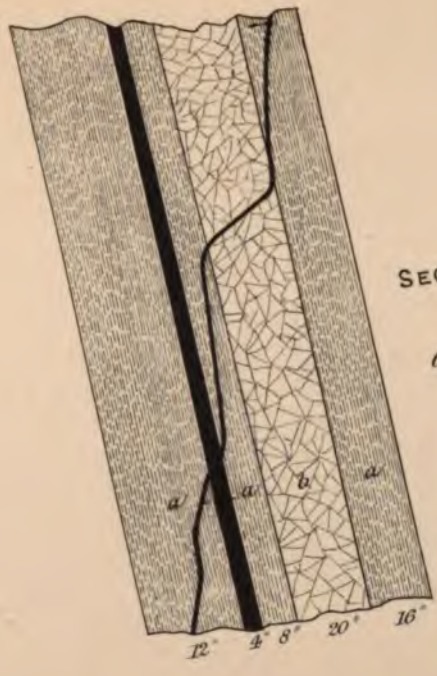
To illustrate Mr. Edwin Gilpin's paper "On the Gold Fields of Nova Scotia."

FIG. 1.



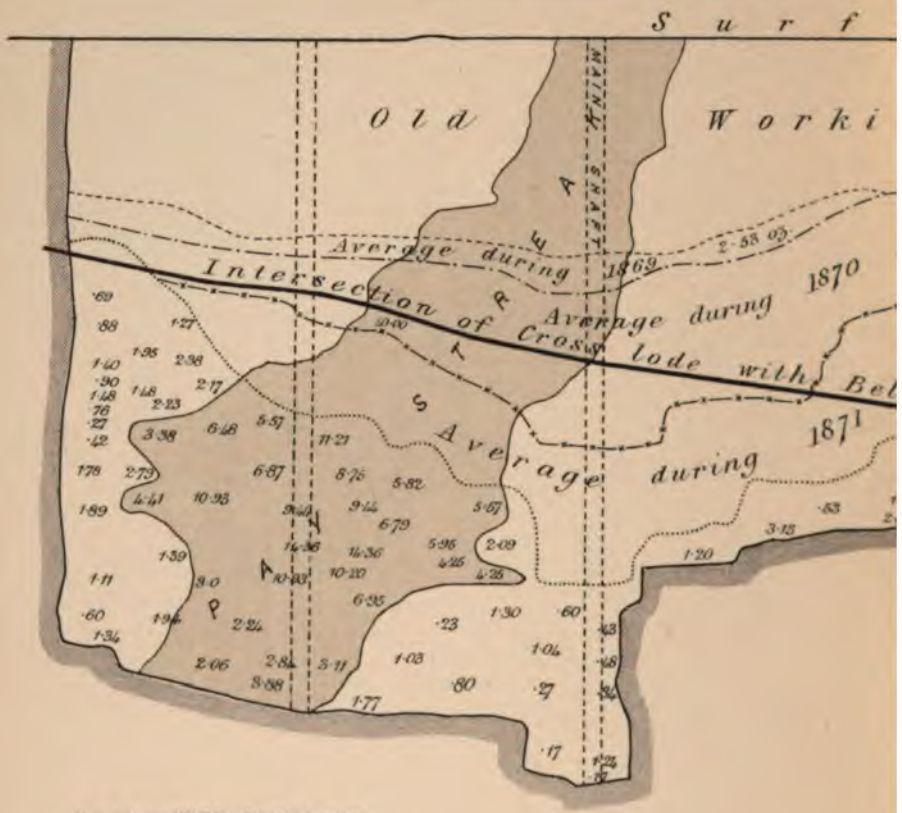
SECTION OF "BULL" VEIN,
pinching Nugget lode,
Mt. Uniacke.
a, Slates—b, Quartzites,
c, Bull Vein—d, Nugget Vein.

FIG. 2.



SECTION OF "BELT" LODE,
showing Cross lode.
a, Slate—b, Quartzite,

To illustrate Mr. Edwin Gilpin's p



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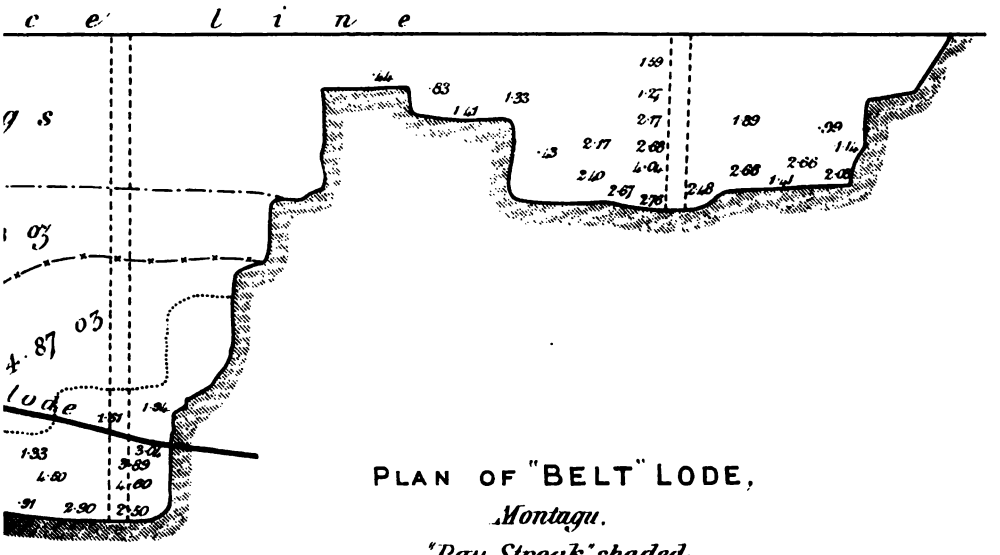


PLAN OF "BELT" LODE,

Montagu.

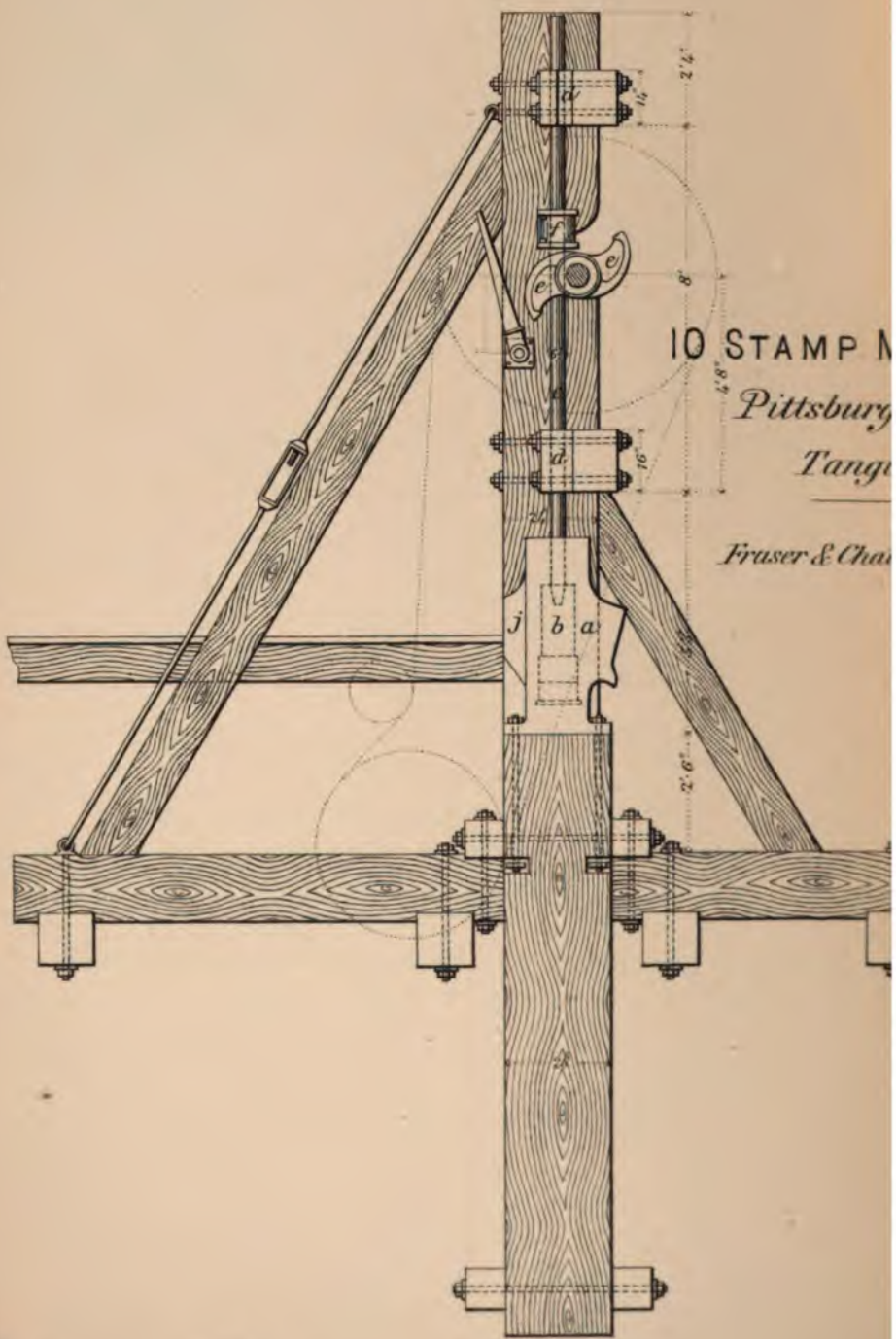
"Pay Streak" shaded.

Scale 80 feet to one inch.

Figures show yield of quartz in ounces per ton.

And. Reid Newcastle.

To illustrate Mr. Edwin Gilpin's pap



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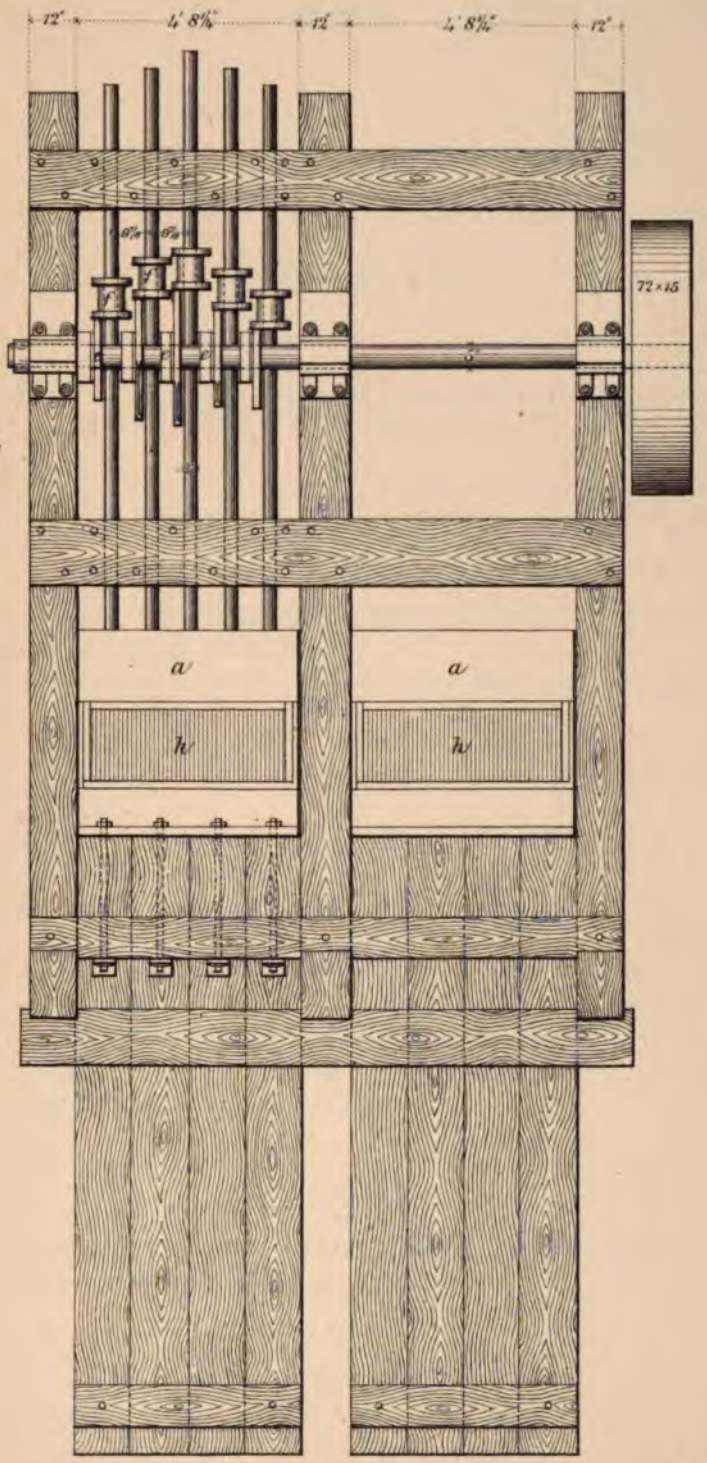


PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 10TH, 1882, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN MARLEY, ESQ., IN THE CHAIR.

The ASSISTANT-SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBER—

Mr. JOHN HARBOTTLE, Manager, Skelton Park Mines, Marske-by-the-Sea.

ASSOCIATE—

Mr. RICHARD L. WEEKS, Willington, Co. Durham.

STUDENT—

Mr. CHARLES FORSTER, Backworth House, Newcastle-on-Tyne.

The following were nominated for election at the next meeting:—

ASSOCIATE—

Mr. THOMAS HENRY WARD, Manager, Kuldiha Colliery, Bengal, India.

STUDENT—

Mr. FRANK MARSTON, Bromfield Hall, Mold.

The ASSISTANT SECRETARY read the following paper, by Mr. E. F. Melly, "On the Anthracite Coal of South Wales:"—

THE ANTHRACITE COAL OF SOUTH WALES.

By E. F. MELLY.

During the past year a vigorous crusade has been undertaken in London against smoke and its companion, fog, and the National Health and Kyrle Societies, under the Presidencies of the Duke of Westminster and Prince Leopold, have originated a movement with a view to the abatement of smoke, in which they have been assisted by the Anthracite Coal Owners of South Wales, who advocate this fuel as the only satisfactory preventative of the smoke nuisance. In the following paper the writer has endeavoured to give a general description of anthracite, its mode of occurrence, its distinctive qualities, and its uses, together with such statistics as it has been possible to collect. It is only to be regretted that the great prejudice against anthracite has prevented the same interest being taken in it as has been bestowed on other coals, while it is a lamentable fact that the production in South Wales is, at the present time, considerably less than it was twenty-five years ago, although there is no doubt that the consumption is again slightly on the increase.

DEFINITION OF ANTHRACITE.

The word anthracite is derived from the Greek ἄνθρακε, signifying carbon or charcoal. It would appear to be a somewhat difficult matter to give an accurate description of the coal, owing to the fact that it varies much in quality; but the following distinctive features are a good indication of anthracite proper:—

1.—Shiny, bright appearance.
2.—Hard and brittle.
3.—Entire smokelessness.
4.—High specific gravity.
5.—Perfect cleanliness.
6.—Large excess of carbon.
7.—Low percentage of sulphur and ash.

In appearance it is either flinty and massive or woody, the former

being by far the harder variety. It is somewhat difficult to light, but once burning develops great heat, which can be greatly increased by the use of a strong draught. It also decrepitates in burning, and this is one of the chief obstacles to its use. This property is supposed to be due to the presence of water between the fibres of the coal, which water on becoming heated, is converted into steam, and thus splits up the coal.

There are several other names for anthracite, such as "stone coal," the "Kilkenny" coal of Ireland, and the "blind coal" of Scotland, while in Wales it is sometimes called "culm," though this name is only applied to the rubble or small.

It is found in very large quantities in the United States, the best deposits being in Pennsylvania, where it is the chief fuel. The present consumption in the United States, for all purposes, now amounts to about 28 million tons per annum. It is also worked in France and Russia, and there are considerable quantities to be found in Germany, Spain, Italy, and Austria. It is, however, only with the anthracite of the United Kingdom that this paper has to deal, and the deposits in Ireland and Scotland being both limited and poor in quality, the vast resources of South Wales alone seem worthy of attention.

HISTORY.

The first mention of the use of anthracite is in Mr. George Owen's "History of Pembrokeshire," written in 1595. After extolling its smokeless properties, he states that some was taken "to the citie of London, to the late Lord Treasurer Barley, to shewe howe far the same excelled that of Newcastell, wherewith the citie of London is servid, and I think if the passage were not soe tedious there would be greate use made of it." Two hundred and fifty years later, Taylor, in his "Statistics of Coal," prophecies its general adoption in London. Little coal was, however, worked, except in Pembrokeshire, for many years on account of the want of outlet; but the formation of the Swansea canal in 1796, the Neath canal in 1800, the Gwendraeth Valley canal in 1825, all of which are now supplemented or superseded by railways, and the Llanelly railway, in 1840, gave an outlet to the entire basin, and a ready communication with the ports of Swansea, Neath, Llanelly, Pembrey, and other parts of the kingdom.

There would appear to have been a heavy spurt in the trade at this period, leading to the opening out of a large number of collieries, which, perhaps, accounts for the present very small individual output of most of them, and the fact that many have come to grief through want of trade.

MODE OF OCCURRENCE.

A few words may be devoted to describing the gradual transition from the highly bituminous coals in the east to the anthracite. The coal-field commences near Pontypool, in Monmouthshire, with coals of a highly bituminous character. Passing gradually to the west, the semi-bituminous coals of Ebbw Vale and Tredegar are first found, and these appear to merge into the celebrated smokeless steam coal of Aberdare and Merthyr. South of this point the Rhondda Valley produces both steam and bituminous coals. Proceeding westwards from Aberdare there is a considerable district at Hirwain and the Neath Valley of *bastard* anthracite, a coal which is intermediate in analysis and quality between steam coal and pure anthracite. It fetches a price equal to second-class anthracite, and is used for mixing with other good coals for steam purposes. This passes on to the anthracite deposits, which continue without interval (except the sea) along the north rise to St. Bride's Bay.

The writer is unaware of any *really* satisfactory explanation for this change in the quality of the coal. One explanation is that it may be caused by friction, produced by the pressure of superincumbent strata, or from internal disturbances; but as the anthracites are in many cases rather nearer the surface than the other coals, and, with the exception of Pembrokeshire, are by no means disturbed, this explanation cannot be considered a good one.

The following analyses of typical coals in each district show, however, how the hydrogen and oxygen have been gradually eliminated, and the carbon consequently increased. In the case of the bastard anthracite, it would appear that the carbon has been partly replaced by ash, this coal being much dirtier than either anthracite or steam coal.

Analyses of a Newcastle bituminous coal and an American anthracite are added for the sake of comparison.

TABLE I.—ANALYSES.

District	Newcastle.	Monmouth.	Aberdare.	Hirwain.	Cwmaman.	Pembroke.	American.
Colliery	Hartley.	Abercarn.	Nixon's.	Dunraven.	Garnant.	Kilgetty.	Beaver Meadow.
Quality	Bituminous.	Semi-bituminous.	Smokeless Steam Coal	Bastard Anthracite	Anthracite.	Anthracite.	Anthracite.
Carbon ...	81·85	85·98	90·27	88·37	92·66	94·18	91·05
Hydrogen ...	5·29	4·70	4·12	3·63	2·12	2·99	3·63
Oxygen ...	7·53	5·53	2·53	4·01	4·68	·76	
Nitrogen ...	1·69	·90	·63			·50	
Sulphur ...	1·13	·59	1·20	1·09	·12	·59	·07
Ash	2·51	2·30	1·25	2·90	·42	·98	5·25

The district of anthracite collieries in South Wales is very extensive, but the greater number of them are mere openings in the side of a hill, connected with an incline, to screens at the railway siding. A great many of these are stopped for want of trade three days per week during certain parts of the year, when the demand for lime-burning in France, or malting in England, is slack.

Referring to Plate XXIX., it will be seen that the anthracite deposit commences on the east near Glyn Neath, in Glamorganshire, and passes westwards some thirty miles to Kidwelly, in Carmarthenshire. Here it is lost under the waters of Carmarthen Bay and re-appears again at Saundersfoot, in Pembrokeshire, crosses that county, a distance of about twenty miles, and finally disappears along the shores of St. Bride's Bay.

This may be divided into three main districts, producing anthracite of varying quality. (1) Pembrokeshire. (2) The Gwendraeth Valley, in Carmarthenshire. (3) From thence eastwards, including the Cwmaman Valley, the north of the Swansea Valley and South Breconshire, extending to the Vale of Neath.

(1.) PEMBROKESHIRE.

The strata in this county are much disturbed and broken up by large faults, and the seams of coal, although of the very best quality of anthracite, are, with the exception of about four, too thin to be worth working. Fig. 1, Plate XXX., gives a section at the Moreton colliery, near Saundersfoot, the Kilgetty seam being added on at a depth of fifty yards, as proved at a neighbouring colliery. Although there are several seams of great thickness, they are found to be too dirty to work.

The Lower-level and Kilgetty seams are the two chiefly worked, and are much harder than the others, producing respectively 50 per cent. and 40 per cent. of large, while many of the other seams produce almost entirely small. The cost of working is very high on account of the thin seams, but, as will be seen further on, the excellent quality and high reputation of the coal enables the owners to obtain a much higher price than that paid for the other anthracites. Fully one-half of the production in Pembrokeshire is used for house purposes in that county, while the large coal is shipped at a high price for malting.

(2.) THE GWENDRAETH VALLEY.

There are a large number of excellent seams of coal in this valley, as may be seen by reference to Fig. 2, Plate XXX. They differ from those in Pembrokeshire chiefly in their hardness, it being a usual thing to produce only about 15 per cent. of small coal, beyond what is made in hewing, and

which is left underground. The percentage of carbon is also lower. Near Llanelly these anthracites are somewhat inferior, but the coal in the north-eastern portion of the valley, though not quite so good as that of Pembrokeshire, is well adapted for malting, a process which requires the best anthracite.

The chief seams are the "Big Vein," the "Stanllyd," and the "Pump Quart." There are few faults, and the collieries are not as a rule much troubled with water, while labour being much cheaper than in the steam coal districts, the cost of working is very low. Besides the seams shown in the section there are several others, amounting it is said to no fewer than twenty-two in all, so that the quantity of coal in this district is very large.

It is, however, a deplorable fact that there are many collieries in the Gwendraeth Valley which have been stamped as failures, and are now no longer at work, while very few work as much as 80 tons per day.

(3.) FROM THE GWENDRAETH VALLEY EASTWARDS, ETC.

The district of most importance in the third section is the Cwmaman Valley, where the largest and most profitable collieries are situated, some of which have an output equal to 250 tons per day. There are a large number of seams varying from one to nine feet thick, while near the Vale of Neath one of these seams attains the thickness of eighteen feet. Amongst these the "Big Vein" (answering to the Stanllyd of the Gwendraeth Valley) has the greatest reputation, while the "Brass Vein" and "Diamond Vein" are also of excellent quality. The "Furnace" or Four-feet seam, supposed to be the same as the celebrated "Four-feet" of Aberdare, has been largely used for iron smelting, with very economical results, and is now shipped for the same purpose to Maryport.

The cost in this valley is also low, and nothing but the restricted demand prevents large profits from being made.

Proceeding eastwards to the boundary of the district, the coals are found to be rather inferior, the percentage of carbon being lower. They are, however, very hard and well suited for lime burning; the seams are the same as those of the Cwmaman Valley.

QUANTITY OF ANTHRACITE WORKED.

During the past few years, no absolute statistics of the quantities of anthracite worked have been made out, but the following, which appear however to be only approximate, have been obtained from Mr. Robert Hunt, and show the production twenty years ago:—

	Tons.
1855	997,500
1856	964,500
1857	960,500
1858	737,590
1859	800,350

These the writer has ventured to supplement by the following Table, which has been prepared with the help of the Mineral Statistics for 1879 and 1880. Although, in the case of Glamorganshire and Carmarthenshire, the figures are not absolutely accurate, yet it is believed that they are very approximate :—

TABLE II.—QUANTITIES.

County.	No. of Collieries in South Wales.		Total Anthracite Coal.		Total Coal in South Wales.	
	Anthracite.	Total.	1879.	1880.	1879.	1880.
Pembroke	7	7	84,573	79,386	84,573	79,386
Carmarthen ...	26	41	360,000	359,800	631,967	625,933
Brecon	6	8	32,456	40,179	83,571	100,616
Glamorgan ...	13	304	165,000	196,000	12,368,187	15,320,196
Monmouth ...	...	82	...	...	4,660,745	5,039,549
Total ...	52	442	642,029	675,365	17,829,043	21,165,680

Average daily output of anthracite collieries ... 46 tons.
Average daily output of all collieries ... ... 172 „
Allowing 280 working days per annum.

It will be seen that the output of the anthracite collieries is wretchedly small, and that the total annual quantity produced does not amount to ·5 per cent. of the total output of Great Britain. The only explanation of the great diminution of the output appears to be that iron smelting in these districts is almost a thing of the past, whereas twenty years ago large quantities of iron were made with this coal.

According to the report of the Coal Commission, there was in 1863, a quantity of 215 millions of tons of workable coal remaining in Pembrokeshire; but allowing for the very tender quality of coal in this district, added to the large number of faults, it is believed that this estimate of *workable* coal is much too high.

The coal in Carmarthenshire and Glamorganshire, however, has not the fault of being tender and would appear to be easily obtainable, as the seams are thick and the faults few. The anthracite district in these counties extends over an area 30 miles in length, with an average width of nearly six miles, giving a total area of over 100,000 acres. The total thickness of the various workable seams of coal proved at different points amounts to over 45 feet, so that it is believed that an estimate of 30,000 tons per acre (allowing 1,000 tons per foot per acre) will be well within the mark. This will give a total of 3,000 millions of tons, from which must be deducted the workings which have already occurred, but the statistics above show that they can have made but a slight inroad into this enormous mass of mineral fuel.

MODE OF WORKING.

There are two main plans of working anthracite, the oldest and most usual of which is the "pillar and stall" system, with what is called "single road stall." This is shown in Fig. 1, Plate XXXI. After leaving the shaft pillars, headings are generally driven off the main levels to the rise, at a distance apart of about 90 yards. From these, leaving only a pillar of 15 yards or less to the level, stalls 7 yards wide are opened out, the pillars between them being generally about 6 yards. These stalls are driven forward about 45 yards, a road being laid on one side, to meet the corresponding stall from the next heading, and are timbered according to the strength of the roof, with props or "sets" of three, and the small coal, which is worth very little, is thrown into the "gob" at the side. As the trams are usually very large and weigh about 30 cwts. when loaded, it is customary to make these stall roads sufficiently high to admit of the horse or pony coming right up to the face, while the collier has no duties beyond getting, filling, and timbering. Nothing is paid per yard of advance after the stall, which commences only 6 feet wide, is once opened out; the price paid for opening off the heading being from 10s. to £1. From 1s. 4d. to 2s. is paid for each "set" of three timbers. When the stall has met the corresponding stall from the next heading, the pillar is driven across, and as much of it brought back along the same road as the roof will allow. If the roof be strong it is nearly all extracted, but in many cases nearly the whole of it has to be left, which makes this system a very wasteful one.

The ventilation is effected by holings from stall to stall. These are made only 4 or 5 feet square, and are driven very cheaply. The lowest stall is thus connected to the return air-way, while a door is placed at the entrance of each stall from the heading.

The "double road stall," Fig. 2, Plate XXXI., only differs from the preceding in the fact that the stalls are generally about 20 yards wide with a road on each side, the space between being packed as much as possible with rubbish. The pillars are from 15 to 20 yards wide, and when the stalls have proceeded about 60 yards to the barrier provided for the heading above, they are cut across and brought back: they have a much better chance of being extracted than in the former method, while the ventilation is much more satisfactory and proceeds up one side of the stall and down the other.

One great objection to the pillar and stall system, and one that exists throughout South Wales, is the large face required in proportion to the number of men, it being very difficult to get two men to work together in a 7 yards stall, or three in a 20 yards stall.

The other method is that of "long-wall," which is coming more and more into fashion, and is especially adapted to flat and thin seams. The working places or stalls are, as a rule, about 15 yards wide for each set of men, and a gob road is kept open for each. These roads are cut off by cross roads, which are made through the gob every 60 yards, so as to save the cost of maintenance. The air as usual circulates round the faces, with occasional splits as the distance becomes greater.

WORKING BY CONTRACT.

It is a very usual plan to let out the whole work to three or four contractors, who agree to deliver the whole of the coal into truck at a certain figure per ton. This appears to be a very bad plan, but it has been found to work well in several cases, while it has on the other hand often been the ruin of the underground workings, and caused the loss of large tracts of good coal. The usual heads of such a contract are as follows:—

1.—This contract includes all the cutting of the _____ seam of coal, driving headings, airways, turning stalls, driving through faults, (provided such faults do not exceed the thickness of the seam), pumping and hauling water, clearing falls, filling and discharging rubbish from the levels.

2.—The contractors are to find horses, pit wood, timber for doors and tram repairs and all other necessary purposes, and all grease and oils and other stores required.

3.—They are to keep clear all air courses and keep the ventilation good, and to keep all the works in thorough repair.

4.—They are to follow the directions of the manager, and to drive headings and stalls according to his orders, and keep to the measurements decided on from time to time.

5.—They are to be responsible for all damage that may arise from the carelessness of their men, and to be liable for all accidents during the term of this contract.

6.—If the manager finds that any work has not been properly done, he may employ other persons to carry out the same properly and charge the cost to the contractors.

7.—The contractors agree to work not less than 100 tons per day of large coal: the proportion of small coal brought to bank not to exceed 15 per cent. of the large.

8.—The contract to commence on_____and the term to be for one year. Payments to be made on the first Saturday of each month, to the amount of 90 per cent. of the work done up to the end of the previous month.

9.—The contractors to find two sureties of £250 each as a security for the proper execution of the contract.

COST OF WORKING.

The cost at most anthracite collieries (exclusive of Pembrokeshire) is very low. The getting price of course varies a good deal, but in several collieries known to the writer it is less than 1s. 4d. per ton on large coal, the small being extracted by "Billy Fairplay," and worked free. The day wages of mechanics and enginemen only amount to 4s. per day, and are often less; while the hauliers, repairers, and colliers taken from their work for other purposes are only paid 3s. 6d. It should be mentioned, however, that the *whole* of the workmen at a colliery partake of the rise and fall of wages under the sliding scale arrangements.

Considering the prices obtainable for the coal the royalties and wayleaves would appear to be rather high, being often as much as ⅛d. and 1d. per ton on all the coal drawn. The following cost sheet is that of a colliery working anthracite under peculiarly favourable circumstances, being entirely without water and requiring only one small hauling engine to deliver the coal at the screens. It would, of course, be much less were the output increased, as it might easily be:—

COST SHEET OF_____COLLIERY.

OUTPUT FOR MONTH ENDING_____

	Tons.
Large	980
Small	220
Total	1,200

	Cost per Ton. s. d.	s. d.
UNDERGROUND—		
Getting	1 0·85	
Yard work	3·40	
Overman and fireman	1·40	
Haulage	2·86	
General repairs	3·28	
		1 11·79
SURFACE—		
Smiths and joiners	1·88	
Screening	2·40	
Sundries and 5 per cent. advance ...	2·04	
		6·32
STORES, &c.—		
Timber	2·50	
Oils and sundry stores	0·50	
Horse hire and keep	2·50	
Royalty and wayleave	8·00	
Rates and taxes	1·45	
Management and office expenses ...	3·63	
		1 6·58
Total		4 0·69

Although in some cases a little gas is found in anthracite collieries, yet an explosion is almost unheard of, and they are generally worked with open lights. Their working is certainly attended with less danger than that of the other South Wales collieries, as will be seen by the following Table, showing the deaths in 1879 and 1880, in proportion to the coal raised: the higher proportion in 1879 was due to one shaft accident killing three:—

TABLE III.—ACCIDENTS.

Year.	Total Deaths.		No. of Collieries.		Tons of Coal Raised per Death.	
	South Wales	Anthracite.	South Wales.	Anthracite.	South Wales.	Anthracite.
1879	270	11	...	...	66,037	58,366
1880	418	4	442	52	50,444	163,841

USES OF ANTHRACITE.

It is difficult to arrive at any reliable figures showing the proportionate use of this coal, but the following have been provided by a gentleman who has a large connection and trade in all the various uses of anthracite, and it is believed that they are substantially correct:—

	Per Cent.
1.—Lime burning	45
2.—Malting	30
3.—Hop drying	3
4.—House purposes	10
5.—Steam	7
6.—Iron smelting	5
	100

(1.) LIME BURNING.

This is the main use of anthracite coal, which is almost the only fuel adapted to this purpose on account of its smokeless properties, as it is so disagreeable to the men to stand over the furnaces from which heavy clouds of smoke are rising, while a great heat and a durable fire are also considered necessary.

It is largely shipped to France, chiefly during the spring, and is used throughout the lime kilns of South Wales.

(2.) MALTING.

This process consists of the gradual drying of barley which has been previously allowed to soak in water for two days, and then laid out for another ten days, during which time it begins to sprout. The malt kiln consists of a brick chamber laid with perforated tiles, and the products of combustion find their way through these holes, and through the barley, which is thus gradually dried. The furnace is at some depth below the drying chamber and the products of combustion are directed by iron plates, so as to spread uniformly in their passage through the tiles; the drying process takes 48 hours. As smoke would damage the malt it is important that the fuel be absolutely smokeless and as free from sulphur as possible, and as the fires have to burn with a long steady heat for many hours, a low percentage of ash is also very desirable. These advantages, added to that of great heat, are possessed by good anthracite, and no other coal is ever used for this purpose, while coke is used to a small extent in some districts.

(3.) HOP DRYING.

This process is similar to the preceding, and the same remarks will apply. It, however, only takes place during a short portion of the year

—from the middle of August to the end of September—and as the fires are not required so long, the anthracite is not necessarily so pure and strong as that used for malting.

(4.) HOUSE PURPOSES.

There appears to be no doubt that the peculiarly noxious character of London fogs is owing to the atmosphere being charged with particles of unconsumed carbon, which have escaped in the smoke of domestic and other fires. Although there have been several inventions more or less capable of preventing smoke, yet the only satisfactory cure is the use of anthracite smokeless coal. There are, no doubt, several difficulties attendant on the use of this fuel, the chief of which is that of lighting it, but by taking the following precautions these are easily surmounted. It requires a rather large fire-place, which should have fire-brick sides, as the strong heat is apt to destroy the iron, and a good draught, which can always be easily produced by the use of a "blower" or piece of sheet iron placed over the top of the fire. The best way to light the fire appears to be with a moderate quantity of wood and a red hot iron or salamander, as a strong heat is required. The pieces of coal should be about the size of an egg, and the fire should be replenished moderately before it gets low. It must not be poked, a pleasure which many Englishmen, who regard the poker as a domestic institution, will be obliged to deny themselves, but the ashes must be gently raked out.

The writer has recently visited the Smoke Prevention Exhibition at Manchester, and there saw several excellent fire-grates and stoves for burning anthracite coal, the best of which appears to be that of Mr. Crane, shown in Fig. 1, Plate XXXII. The spaces on each side of the fire-place usually filled with brick-work, are occupied by side flues communicating with the bottom of the grate. When the register door is closed, a strong draught is circulated, and the products of combustion are conveyed down the side flues, and directly under the fire, part being again drawn through the fire, and the remainder finding its way into the chimney through an opening below the level of the grate. The register door should be opened when the fire is well alight; the heat is very great, and as the fire lasts a long time there is a very great economy.

In many parts of Wales this coal is universally used for house purposes, and the writer has received several letters from persons who have used it for years, and infinitely prefer it to bituminous coal on account of its cleanliness. In Pembrokeshire it is usual to mix the small coal with

moist clay and form balls, which when ignited with the help of a little wood, get red hot, and make an excellent and enduring fire. They are frequently seen in the cottages of the poor, and they have a resemblance to, but much better effect than the ordinary coke fires.

(5.) STEAM.

There are two main obstacles to the use of anthracite for steam purposes. First, the great local heat which destroys the bars, and secondly, its slow combustion. In 1847 the steamship "Washington," belonging to the American line running from Southampton to New York, started with anthracite coal, and a fan to promote rapid combustion; but within a few hours she was back in Southampton with her bars utterly destroyed by the great heat. In 1854 Messrs. McClarty, of Liverpool, used anthracite for two years, apparently with great success, without any artificial draught, and found a saving of 20 per cent. in stowage, and a reduction in consumption of over 40 per cent. The general business of the firm proving unprofitable, this successful use of anthracite came to an end.

About this time Dr. Frankland, after a series of experiments, gave the following figures as comparison of the evaporative power of various coals per cubic foot of stowage in steamers:—

	Lbs. of Water evaporated by 1 Cubic Foot of Coal.
Duffryn, Welsh steam coal	568·02
Graigola	581·20
Nixon's Merthyr	514·93
Lyon's patent fuel...	585·33
James and Aubrey's anthracite	565·02
Watney's anthracite	742·36

thus showing the great superiority of anthracite.

It was also used in 1853 on board the "Victoria and Albert," with the help of steam jets, and gave great satisfaction. The "Great Britain," "Royal Charter," and "Faith," also used anthracite; but in no case has its use continued, the great difficulty being to obtain sufficient draught without burning the bars, it having been found that anthracite without artificial draught requires nearly 60 per cent. more grate surface than other steam coals.

This difficulty seems to have been at length overcome by Mr. Perkins' invention, subsequently improved by Mr. Flannery. Referring to Fig. 2, Plate XXXII., it will be seen to consist of a series of hollow perforated bars, resting on a hollow dead-plate and hollow bridge. *a* is the main pipe conveying air from the fan, *h* the branch pipe to the bridge *c*. The air enters the bar at each end and passes into the fire through the per-

forations, while portions also pass through the furnace door *f* and through the bridge at *e*, to allow of an extra supply of air, anthracite being more liable than any other coal to give off partially consumed gases.

This system is found to answer excellently; the fiercer the combustion produced by the blast, the cooler is the bar on account of the large supply of air passing through, while the economical results have been proved by experiments on board Messrs. Penn's steamer "Elephant."

The following experiments were made in 1874 with a small tubular boiler, of which the dimensions were as follows:—Length 11 feet 9 inches, diameter 4 feet 5 inches, tubes 4 feet 7 inches long, area of fire-grate 9½ square feet. The steam was kept at a pressure of about 40 lbs.

TABLE IV.—STEAM EXPERIMENTS.

Coal.	Ordinary Bars.		Anthracite Coal and Patent Bars.			
	Birch Grove Coal	Powell Duffryn.	No Blast.	Small Fan.	Blower ½ Open.	Blower Full Open.
No. of Experiment	1	2	3	4	5	6
Lbs. of water evaporated per lb. of coal... ...	7·06	7·83	7·94	7·98	8·14	6·56
Lbs. of water per hour ...	672	745	594	960	912	1,204
Horse-power produced ...	10	11	9½	15	14	19

A reduction of 1 per cent. should be made from Nos. 4 and 5 for the steam used for the blower, and of 2 per cent. from No. 6. It would thus seem that the patent bars, with a moderate blast, give the best results.

Since these experiments a steam jet has been adapted to the same furnace in the form of a number of jets, one to each bar. This has enabled anthracite *small* to be used under boilers, a fuel quite out of the question, without some artificial draught, while the bars remain cool and uninjured.

Anthracite coal is of course used for steam purposes at all anthracite collieries, and the only complaint is the low horse-power produced. It has also been used by Messrs. Hall and Son at their powder works at Faversham, for the last thirty years. They say that they took to it primarily on account of the absence of smoke and sparks, and they have found that no artificial draught nor other alterations were required in their furnaces, the bars being one inch apart and the pressure of steam 40 lbs.

(6.) IRON SMELTING.

Large quantities of iron were at one time made in South Wales from anthracite coal, and in 1872 over 72,000 tons were used for this purpose.

The iron trade in these districts has, however, now almost ceased, and with the exception of that used in Cumberland and Staffordshire, little anthracite is now used for this purpose. Some of the anthracites do not decrepitate seriously in the furnace, and, with this obstacle removed, their great heat and small percentage of ash and sulphur render them excellent smelting coal, so that their use in the above-named districts is rapidly increasing.

The following are the prices of the various anthracites :—

(1.) PEMBROKESHIRE.—LOWER LEVEL VEIN.

	s.	d.	
Large	12	0	f.o.b. Saundersfoot.
Rubble	8	0	at pit for house.
Small	5	0	„ „

These prices are very high, but the coal is superior to other anthracites.

(2.) CWMAMAN VALLEY.—BIG VEIN.

	s.	d.	
Large	7	0	at pit.
Small	2	6	„
Large	9	0	f.o.b. Llanelly.
Small	4	6	„ „

The "Brass" vein and "Furnace" vein realise 1s. to 1s. 6d. less for large, and 6d. less for small. The Swansea Valley good anthracites fetch about the same prices.

(3.) BRECONSHIRE DISTRICT INFERIOR ANTHRACITES.—9 FOOT VEIN.

	s.	d.	
Large	5	0	at pit.
Small	1	9	„
Large	7	6	f.o.b. Swansea.
Small	4	3	„ „

All the above prices are less $2\frac{1}{2}$ per cent. in thirty days.

It will be seen that there is a good margin of profit, if a sufficient quantity of good anthracite can be disposed of.

It may also be well to give the prices, delivered in London, compared with other coals used for house purposes. It must be borne in mind that the coal should be broken into pieces the size of an egg before delivery, as it is much too hard for this to be done by the housemaid. This breaking up is rather costly, on account of the small made, and is charged for extra at 1s. per ton. In America this is done at the pits by machinery, and the pieces sorted into "lump coal," "steamer coal," "broken coal," "egg coal," "stove coal," "chestnut coal," the value increasing as the size is reduced.

	Prices in Truck at London Stations.		Delivered Into Cellars.	
	s.	d.	s.	d.
Wallsend best ... ... By sea ...			23	0
Silkstone best	16	6	22	0
Wigan	16	0	21	0
Derby brights	14	0	19	0
Kitchen	13	0	18	0
Hard steam	13	6	18	0
Big Vein anthracite	17	0	22	6
„ „ broken to egg size ...	18	0	23	0

The difference between the prices in truck and the delivered prices consists of:—9d. shovelling out of truck, 2s. 9d. screening, cartage and delivery; and the balance represents the merchants' profit and the loss on small coal made in re-screening, which is sold for smithery purposes, at 8s. to 9s. per ton.

It will thus be seen that anthracite is no dearer than the good London house coals, while it is far more economical in burning.

COKING.

Although at the present time no coke is made in South Wales, yet it is interesting to mention several attempts which have been made to coke it. As long ago as 1859, experiments were made at Kilgetty with partial success, and a good deal of anthracite coke was sold for blast furnaces. About ten years after, Messrs. Penrose and Richards, of Swansea, took out a patent for anthracite coke, which was made in the following manner:—Proportions of 60 per cent. of anthracite small, 35 per cent. of bituminous small, and 5 per cent. of pitch were mixed together and crushed in a Carr's disintegrator. The right quantities were obtained by three Jacob's ladders, the buckets of which were made in proportionate size to the quantities required. The ovens used were of the ordinary square type, and the coke, which took about seventy hours to burn, was found to be so hard as to scratch glass, and to be about 23 per cent. heavier than ordinary coke, while the yield is said to have been over 70 per cent. It was used at the Landore Siemens' steel works with good results, the sulphur being exceedingly low, and the economy of fuel being equal to about 20 per cent. On the whole, however, it appears that it was not a commercial success, and its manufacture is now discontinued, except in France, where it is still largely made and used at Creusot.

Amongst other applications for which anthracite is more useful than ordinary coal, may be mentioned the Dowson gas generator. This apparatus produces gas for a gas engine, by passing super-heated steam,

at a pressure of about 25 lbs. on the square inch, into a grate burning anthracite, fixed at the bottom of a generator made of cast iron. A quantity of air is also drawn in, and the steam is decomposed and forms with the carbonic oxide a gas which has a great heating effect, though low illuminating power. It is then passed through scrubbers to a gasometer. Anthracite, on account of its high percentage of carbon, is most suitable and economical, and it is stated that 12 lbs. of it will produce 1,000 cubic feet of gas at a cost of a ½d. per horse-power per hour.

In conclusion, the writer would venture to point out that experiments and practise have satisfactorily proved that anthracite, used with proper appliances, is a cheap and efficient fuel for most purposes, and, on account of its smokelessness and cleanliness, eminently suitable for domestic use, while it appears certain that as the best steam coal of Aberdare becomes exhausted, it is certain to take its place.

He would also offer his best thanks to several gentlemen who have given him great assistance in the production of this paper, which it is hoped may be of interest to the members of the Institute.

Mr. T. W. Bunning said, that he did not think that the use of anthracite would be a satisfactory mode of reducing the smoke nuisance in London, since it could only diminish the visible, and probably the least injurious, portions of the products of combustion, which products within a small fraction of a per cent. were invisible, and it seemed to him that the combustion of the same quantity of any sort of coal would produce approximately the same results both in the quantity and nature of the deleterious gases evolved. In fact these deleterious products would be 7 per cent. greater in the Kilgetty anthracite, which by the table given in page 177 is shown to contain the most carbon, than in the Hartley bituminous coal. In order to give some idea of the enormous quantities of air changed into noxious gases and poured daily into the atmosphere of London, Mr. Dunn has kindly made a calculation, given in a foot note,* which shows that on a winter's working day, when the consumption

* Gases produced by Combustion of Coal.

Carbon dioxide.—If coal completely burnt, each 1 % carbon produces 3⅔ % CO_2. Hence, 1 ton gives 82·13 lbs. CO_2 = 701·25 cubic feet at 60° F. and 30″ bar.

Sulphur dioxide.—Each 1 % sulphur yields 2 % SO_2. Hence, 1 ton gives 44·8 lbs. SO_2 = 263·8 cubic feet at 60° F. and 30″ bar.

Water vapour.—Each 1 % hydrogen produces 9 % water vapour. Hence, 1 ton gives 201·6 lbs. H_2O = 4,221·3 cubic feet. (Supposed vaporous at 60° F. and 30″ bar.)

Air consumed.—Each 1 % carbon requires 701·25 cubic feet oxygen per ton = 3,500 cubic feet air roughly.

is roughly 30,000 tons, the gases would, if kept together, cover 150 square miles (about the area of London) 7 feet 10 inches deep, if anthracite coal was burnt, and 7 feet 4 inches if Hartley was burnt; one of these gases alone, the CO_2, would render unbreathable fifty times its own bulk of air, that is a column 60 feet high all over London if Hartley was burnt, and 70 feet high if anthracite was the fuel. Fortunately, it is true, that diffusion takes place very rapidly, but it is not to be wondered at that, after two or three calm, damp days in London, the atmosphere

Each 1 % sulphur requires 263·8 cubic feet oxygen per ton = 1,300 cubic feet roughly.

Each 1 % hydrogen requires 2,110·6 cubic feet oxygen per ton = 10,000 cubic feet air roughly.

Thus, the Hartley coal with 81·85 % C, 5·29 % H, 7·53 % O, and 1·13 % S, would take out the oxygen from 81·85 × 3,500 + 1·13 × 1,300 + 4·35 × 10,000 = 331,444 cubic feet of air, and replace it by 57,397 cubic feet CO_2, 298 cubic feet SO_2, and 18,362 cubic feet water vapour, for each ton of coal consumed.

The Kilgetty (Pembroke) anthracite, with 94·18 % C, 2·99 % H, ·76 % O, and ·59 % S, would for each ton of coal consumed take out the oxygen from 94·18 × 3,500 + ·59 × 1,300 + 2·9 × 10,000 = 359,397 cubic feet of air, and produce 66,044 cubic feet CO_2, 156 cubic feet SO_2, and 12,242 cubic feet water vapour.

Hunt states that 10,563,948 tons of coal are sent up to London every year, which, considering that very much more is burnt in the winter than in summer, and on a working day than on a Sunday, represents about 30,000 tons per winter working day.

This from the Hartley coal means the production of

1,721,910,000 cubic feet	=	191,324,000	cubic yards	CO_2
8,940,000 ,,	=	1,000,000	,,	SO_2
558,960,000 ,,	=	62,106,000	,,	H_2O vapour,

and implies the total removal of oxygen from

9,943,320,000 cubic feet	=	1,104,814,000	,, of air,

and from the Kilgetty anthracite the production of

1,981,320,000 cubic feet	=	220,146,000	,,	CO_2
4,680,000 ,,	=	520,000	,,	SO_2
367,260,000 ,,	=	40,806,000	,,	H_2O vapour,

with the total amount of oxygen from

10,781,910,000 cubic feet	=	1,197,990,000	,, of air.

Area of London say 150 square miles = 464,640,000 square yards, so that the thickness of the layers of the products of one day's coal combustion (supposing them to be spread uniformly over this area), and of the stratum of air which would be completely deprived of oxygen, would be as follows:—

	Hartley Coal. Ft.	In.		Kilgetty Anthracite. Ft.	In.	
CO_2	1	2·44	...	1	5·06	(s.g. 1·524)
SO_2		·08	...		·04	(s.g. 2·211)
H_2O		4·82	...		3·20	
Nitrogen remaining	5	8·48	...	6	1·30	(s.g. ·971)
	7	3·82		7	9·60	
Total air consumed	7	1·60	...	7	7·62	

becomes so unbearable as to kill the fat pigs at the Agricultural Show. In fact the smoke proper, or the very small fractional percentage of soot or unconsumed carbon floating about is rather an advantage, as it calls attention to the greater evil arising from the invisible products of combustion, in the same way as the smell of the street gas has saved many thousands of persons from being killed by explosions.

Mr. DUNN said, he did not know that it had been clearly shown how much of the deleterious effects of fog were due to smoke, which was an unconsumed portion of the coal, and how much to what he might call the legitimate products of combustion. So far as these latter were concerned the substitution of anthracite for bituminous coal would be no practical advantage, the difference, with the same consumption of coal, being to increase the evil. There was no doubt that the diminution of the quantity of smoke, if it did not decrease very much the deleterious effects of fog, would help to render it very much less unpleasant while it lasted. It seemed to him that the question of removing the smoke nuisance would be one principally of relative cost. There had been two or three plans proposed by which, if the smoke was not removed it would be lessened, even with the use of bituminous coal. There were Moncrieff's and Siemens' plans, both of which go upon the idea that there should be removed either a portion or the whole of the volatile matter of coal as gas, and that the coke or partially burnt coal produced should be used as fuel, with or without the assistance of a portion of the gas obtained from it. He supposed only a trial of these plans on a large scale, as compared with the use of anthracite coal, would solve the question as to which would be the least expensive and also the most efficient.

Professor LEBOUR said the first paragraph of the abstract of Mr. Melly's paper referred to the de-bituminizing of coal from east to west in Wales. This was a question which had been before the Institute on a former occasion, and one upon which the late President, Mr. Greenwell, had given very valuable information. In the abstract of this paper it was distinctly stated that the further west they went in South Wales, not only was the bituminous character of the coal lost more and more, but that the district became more and more faulty; and attention was drawn to the fact that in Pembrokeshire the faults were both larger and more numerous—a fact which was known, but to which perhaps attention had not been called here in connexion with the de-bituminizing of coal. As to this de-bituminizing of coal, the assumption that the coal had been, one way or another, baked by the heat, might partly account for it. It was not a

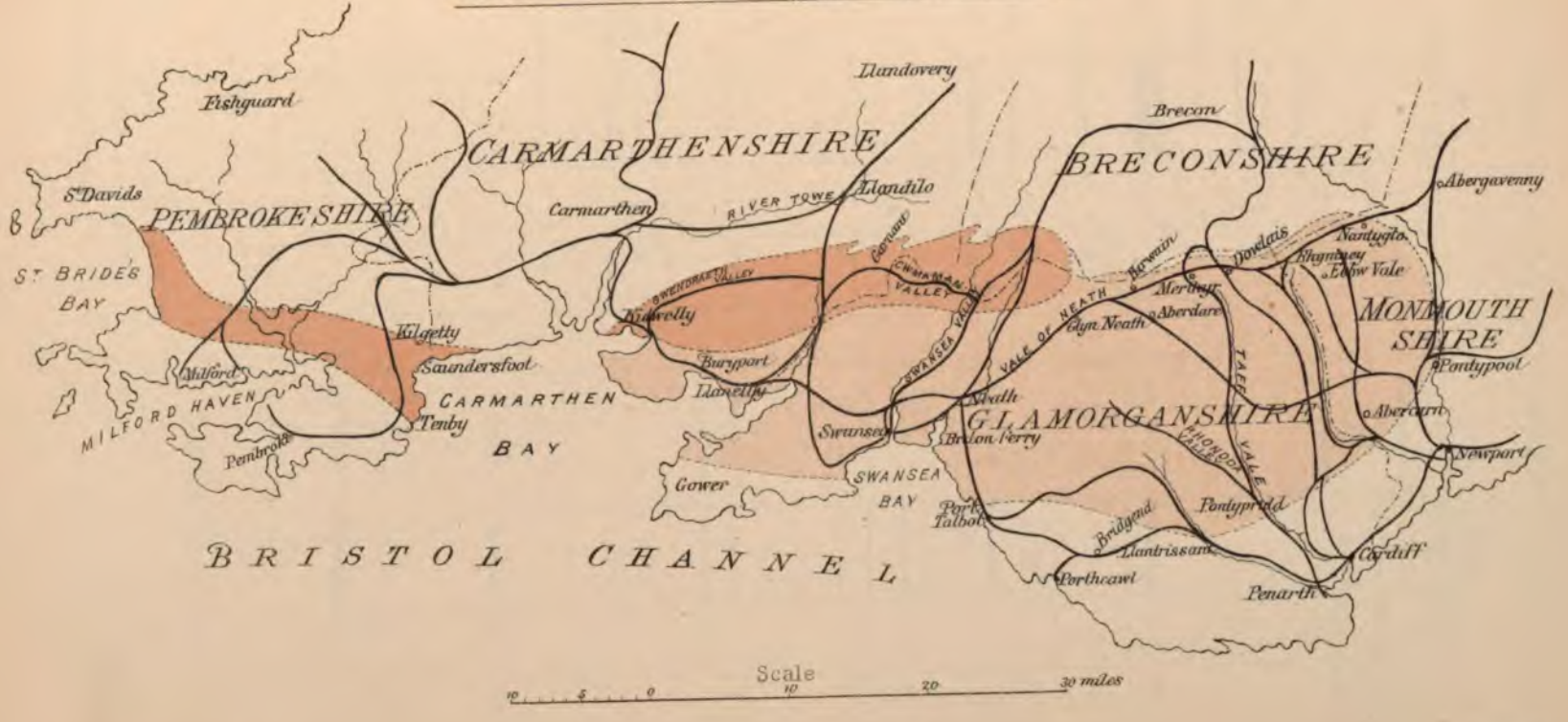
new theory, but this bore out, to some extent, the old theory that the heat which altered this coal—which in South Wales could not be traced to the presence of igneous rocks, as igneous rocks were remarkably absent —might be due to faults in that coal-field. Exactly the same thing was observed in Pennsylvania where the de-bituminizing effect took place from west to east, the eastern part being the most anthracitic, and accompanied by greater contortions, showing that there had been great mechanical action which had certainly not taken place without very great heat, and that heat had probably been quite sufficient to effect the de-bituminization of the coal. It was here sometimes found that the upper part of a seam was anthracitic and the lower bituminous; in cases of this sort it was extremely difficult to assign any reasonable cause for the change with our present sources of knowledge.

Mr. DAGLISH, in reply to Professor Lebour's remarks, drew his attention to the fact that whilst, as correctly stated by him, there was a gradual and marked alteration or de-bituminization of the lower or steam coal seams, viz., the 4-feet, 6-feet, 9-feet, &c., in a westerly direction in the South Wales Coal-field; this change did not apply to the upper or house coal seams, viz., the Nos. 1, 2, 3, Rhondda Seams, &c., which continued of a highly bituminous character over the whole of the true smokeless steam coal district; the characteristic alteration, therefore, in the lower or steam coal seams could hardly be due to any direct igneous action. Where coal seams are known to be affected by igneous action—as, for instance, in the vicinity of the various basalt dykes and whin sills in the North of England and the South of Scotland—the coal is entirely altered in character, and in fact carbonised and turned into coke. This is not the case in South Wales, where the coal is uninjured.

Professor LEBOUR said, he agreed with what Mr. Daglish had said about bituminous seams in Wales overlying anthracite seams, and that was one of the difficulties which had never been solved. It was perfectly true that the character of the anthracite seams was entirely different to that of the coke-coal which was got from the sides of whin dykes. They did not know what the effect would be on coals under great thicknesses of rock; and it was quite possible that this anthracitic change which *had* taken place under such circumstances precluded them from being even compared with those altered coals got nearer the surface in English workings or in Scotland. This de-bituminization was probably due to a number of conditions which they were not acquainted with, or at all events which had not been proved yet. Mr. Daglish would agree that,

To illustrate Mr. E. F. Melly's paper "On the Anthracite Coal of South Wales."

Map of the South Wales Anthracite District.



To illustrate Mr. E. F. Melly's paper "On the Anthracite Coal of South Wales."

Fig. 1.
Pembrokeshire

Name of Seam	Section	Thickness Feet Inches	Depth from Surface Fath. Feet
Rock Vein		3 · 0	58 · 0
Coal		1 · 8	62 · 5
Coal		3 · 0	64 · 5
Timber Low Vein		1 · 6	70 · 5
Dirty Coal and Clay		25 · 0	75 · 3
Timber Vein		2 · 6	86 · 0
Coal		1 · 8	95 · 0
Stinkard		6 · 6	100 · 0
Coal		1 · 3	133 · 0
Coal		1 · 4	142 · 0
Coal		1 · 3	145 · 0
Coal		1 · 9	147 · 0
Lower Rock Vein		3 · 0	149 · 0
Coal		0 · 6	153 · 0
Lower Level Vein		1 · 8	158 · 0
Kilgetty		1 · 4	208 · 0

Scale 33 Fathoms to the Inch

Fig. 2.
Gwendraeth Valley

Name of Seam	Section	Thickness Feet Inches	Depth from Surface Fath. Feet
Big Vein		9 · 0	22 · 3
Green Vein		3 · 0	26 · 0
Ddugaled		4 · 0	44 · 0
Birch Vein		1 · 6	53 3
Stanllyd		3 · 0	56 · 0
Grasuchan		4 · 0	61 · 0
Grasissa		4 · 0	65 · 0
Braslyd		3 · 6	79 · 0
Gwendraeth		2 · 9	83 · 0
Triquart		2 · 3	110 · 0
Little Vein		0 · 10	125 · 0
Pumpquart		5 · 0	130 · 0

Scale 24 Fathoms to the Inch

Ant. Pl. Rich. Newcastle

To illustrate Mr. E.F. Melly's paper "On the Anthracite Coal of South Wales."

FIG. 1.

SINGLE ROAD STALL.

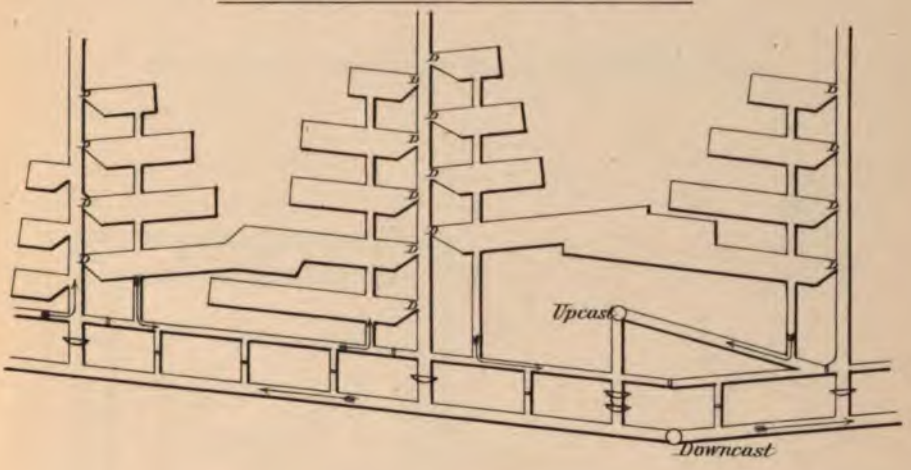
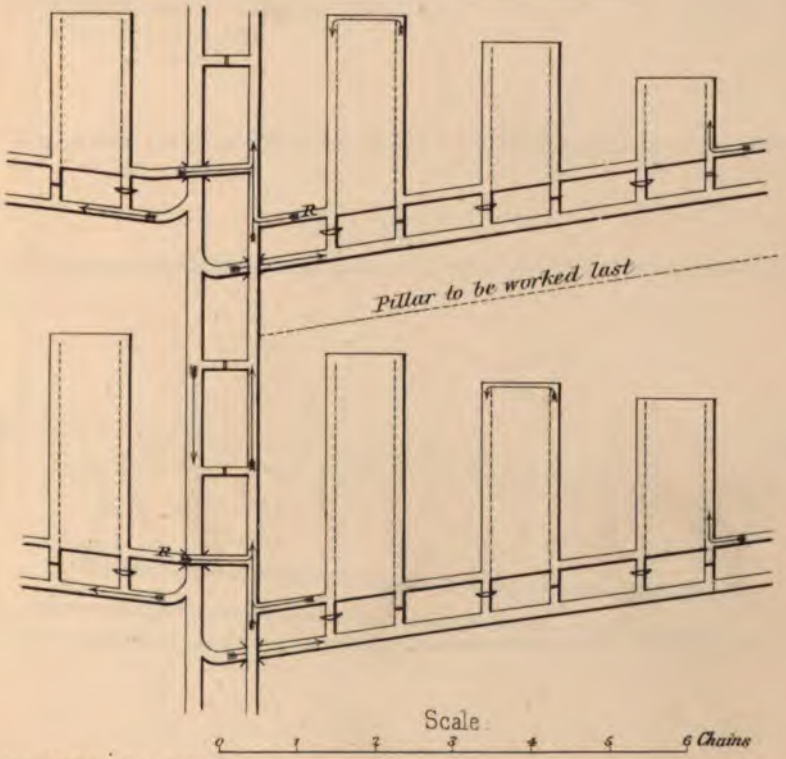


FIG. 2.

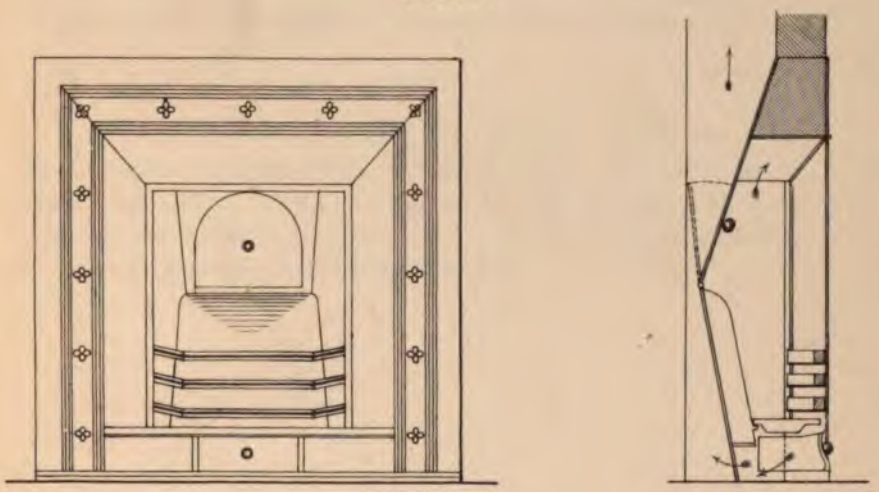
DOUBLE ROAD STALL.



To illustrate Mr. E. F. Melly's paper "On the Anthracite Coal of South Wales."

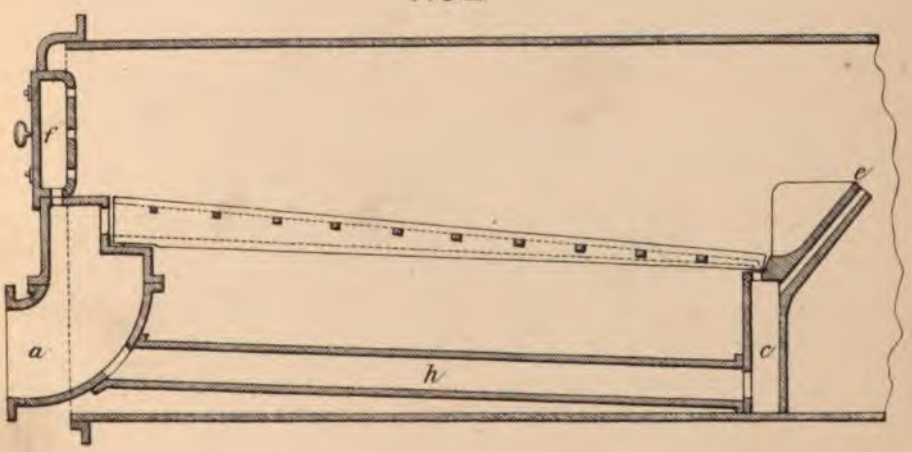
Domestic Stove for Burning Anthracite.

Fig. 1.



Perkins' Steam Boiler Furnace Improved by Flannery.

Fig. 2.



so far, the greater or more intense faults in Wales seemed to accompany and coincide with the greater or more complete de-bituminizing of coal there. What Mr. Daglish had pointed out in regard to the Aberdare Valley was interesting; but there was a stranger fact as to some coals in Pennsylvania, where the anthracite was at the top in a single seam and the bituminous at the bottom, both far removed from any igneous rock of any kind, but in the vicinity of great contortions of the strata.

Mr. T. W. Bunning then read the following "Description of the Fleuss Apparatus for Breathing in Noxious Gases." He said he had to express his thanks to Mr. Corbett for allowing the apparatus to be exhibited, and to Mr. S. H. Hedley for his great kindness in attending and describing to him the use of the apparatus.

THE FLEUSS APPARATUS FOR BREATHING IN NOXIOUS GASES.

By the SECRETARY.

The appliances for enabling persons to remain under water or in vitiated air are shown in Figures 1 to 18, Plates XXXIII., XXXIV., and XXXV., which delineate various views of apparatus suitable for being used by a person having to work in vitiated air or shallow water.

Fig. 1 shows a front view, and Fig. 2 a side view, of a mask, or face-piece, by which the nose, mouth, and ears of the person wearing it can be shut off from the surrounding air. Projecting out from the mask are two pipes, *a*, *b*, one for the inlet of purified air to the interior of the mask, the other for conveying the exhaled vitiated air to the purifying apparatus.

This mask is kept on the face by straps going round the back of the head, and by a bandage passed over the mask from *a* to *b* fastened under the chin of the wearer. This latter fastening is, in the more modern masks, rendered unnecessary by an air-pipe of India-rubber running round, which adapts itself to all the irregularities of the face, and makes a sufficiently tight joint without subjecting the wearer to the unpleasant pressure of the bandage, and this is a very great improvement. In all cases it is better that the person wearing the mask should be without a beard.

The mask, however, is not a comfortable arrangement, and many persons prefer the "goggles" used by Denayrouze to protect the eyes, whilst breathing with the help of the simple apparatus shown in Plate XXXV., Fig. 18. It consists of a tube *a* kept in its place by the band *c;* the two ends of the tube *d*, *e*, serve the purpose of the tubes *a* and *b* in the mask. The flat projection *b* is grasped by the lips and teeth. By this arrangement the wearer is not inconvenienced by the perspiration and water which flood the mask after it has been used for some time, although it subjects the wearer to an emission of saliva which is very difficult to get rid of.

The apparatus for purifying the air is most conveniently arranged to be carried on the back of the wearer in the form of a knapsack, and can be put on, ready for use, in five seconds. It is shown in Figs. 3, 4, and 5, Plate XXXIII., and Figs. 6, 7, 8, and 9, Plate XXXIV.

At the bottom is a strong metallic vessel *c*, about 6 inches diameter and 16 inches long, charged with compressed oxygen, at a pressure of 250 lbs. to the square inch. Above this vessel is a rectangular metallic case *d*. Into the case *d* is fitted a vessel *e*, formed of vulcanite, which is not acted upon by caustic soda.

This vessel, shown more particularly in Figs. 6, 7, and 8, Plate XXXIV., has a perforated false bottom and is divided into compartments by division plates, two of which pass from the top of the vessel to the perforated false bottom, while the central one passes from the bottom of the vessel up to within a short distance from the top.

The compartments of the vessel when in use are filled with tow and caustic stick soda. The vessel is covered with a lid, made air-tight by an India-rubber washer between the lid and vessel. Two pipes pass from the lid; through one of them marked *f*, Fig. 9, the exhaled vitiated air is led into one end compartment, while by the other, marked *g*, the air, after having passed upward and downward through the compartments of the vessel *e*, can pass back to the interior of the mask to be again breathed. The pipe *g* is formed with a branch pipe *g′*, standing out from it, from which a flexible pipe is led to the interior of an air-bag *g″*, Fig. 10. This bag serves as a flexible air reservoir, which will expand when air is exhaled, and contract when air is again drawn from it into the lungs.

The inlet and outlet tubes on the mask are connected respectively to the inlet and outlet tubes on the lid of the vessel *e* by elastic tubes of India-rubber. Each elastic tube has a metal valve, Fig. 12, attached at one end; the inhaling valve opening towards the mask, and the exhaling valve opening away from the mask. Each elastic tube is made with corrugations, as shown at Fig. 11, so that it will readily stretch. The ends of the short tubes on the mask, and on the lid of the vessel *e*, and the ends of the valve pieces, have each a small projecting flange around them, and the ends of the elastic tubes, when simply stretched over these flanges, hold firmly to them and form air-tight joints.

To restore to the air the requisite quantity of oxygen, a small pipe *h*, Figs. 3, 4, and 5, is led out from the metallic vessel *c*, Fig. 4, in which the store of oxygen, under pressure, is contained, and by a flexible pipe connected to it at *h′*, Fig. 4, is led into the flexible tube, which is in connection with the air-bag; a short length of metal tube, such as shown at Fig. 12′, being used where the smaller pipe is led into the larger one.

To control the passage of oxygen from the vessel *c* to the bag, a valve *j* is employed, which can be opened, more or less, as required. This valve is shown in detail in Fig. 13. By turning the screw *j*, Fig. 13, Plate XXXV., the valve can be lifted, more or less, away from its seat, and so a greater or less quantity of oxygen may be allowed to pass out continuously from the vessel *c* through the small tube *h*. The loops *k*, Fig. 10, at the lower part of the bag, are to pass over the studs *l*, at the ends of the vessel *c*, Figs. 3, 4, and 5. The straps at the upper part of the bag are to be buckled together, and form a loop, which hangs over the shoulders of the wearer and is connected to the apparatus at *m m*, Fig. 4.

The lid of the vessel *e*, Fig. 9, is held down and the vessel retained in the metallic case *d* by bars *n*, passed across the top of the case, through eyes which project up from it as shown in Figs. 3, 4, and 5.

When the apparatus is to be used for enabling persons in the ordinary diver's dress to work under water without fresh air, it is modified in the manner shown at Figs. 14 to 18. Fig. 14 shows a side elevation of the ordinary metallic shoulder-piece of a diver's dress, with the apparatus combined with it. There is a clip plate all round the edge of the shoulder-piece, by which the opening at the top of the diver's dress is clamped in the ordinary manner, and a tight joint made between them. Fig. 15 is a front elevation of the helmet which can be secured to the shoulder-piece and locked thereto by giving it a partial turn. Figs. 16 and 17 are, respectively, a face and side view of the mask which is to be secured over the nose and mouth of the wearer inside the helmet.

This apparatus being used for deep-water diving, it is necessary that the case *d*, containing the vessel which holds the caustic stick soda should be closed by a strong metallic cover, with metallic pipes leading to and from it, and the vessel *e*, which contains the caustic soda, is made with a flange round the top. Above the top of the vessel *e* is placed a strip of sheet India-rubber, and above this the metallic cover. The cover is secured by screws as shown at Fig. 14. The pipes which take the foul air to, and convey the purified air from, this vessel, are secured to the headpiece as shown at *a*, Fig. 14.

The purified air passes straight into the dress which serves the purpose of the bag, Fig. 10; and the exhaled air is forced by the lungs through the pipe *y*, Fig, 16, and through a flexible tube, to *x*, Fig. 14, and from thence through the purifying vessel. A small valve is fixed on the mask at *z*, to prevent the exhaled air becoming mixed with the purified air in the dress; and another valve is put on the outlet pipe to prevent the return of the exhaled air before it has become purified. A small pipe

from the oxygen reservoir is also connected by a union to the shoulder-piece, and a continuation leads into the interior of the helmet. As the mask or mouthpiece, Figs. 16 and 17, is not required to protect the eyes, it is made smaller than the one shown at Figs. 1 and 2.

d, *d*, Figs. 4 and 14, are metal loops on the exterior of the oxygen reservoir, through which a belt may be passed and buckled round the waist of the person using the diving dress.

As this apparatus could not be successfully used in dark places without some means for obtaining light, a lamp has been devised which will burn when surrounded by gases which will not support combustion.

This lamp is illustrated in Plate XXXVI. It consists of a metallic sphere *c*, which serves as a reservoir for compressed oxygen, and upon this sphere is fixed a spirit lamp *d*, with a movable pin *e*, for carrying a lime, and a movable platinum tube *f*, capable of adjustment for directing the stream of oxygen through the flame of the spirit lamp on to the lime. This platinum tube *f* forms the extremity of a tube *g*, which traverses the spirit reservoir of the lamp *d*, passes into the sphere *c* containing the oxygen, and communicates with a jamb cock *h*, which is capable of adjustment from without the sphere *c*, and controls the stream of oxygen for producing a small or greater light at pleasure. The reservoir of the spirit lamp *d* forms part of the spherical oxygen reservoir, and has on its outer part a screw thread and collar *i*, on to which is screwed a double hood *k*, *k'*, the joint being made air-tight by means of a washer. This hood *k*, consists of an elongated cylinder with domed top and flanged base, with a screw ring *l*, within, by means of which it may be attached to, or detached from, the screw thread and collar *i*, on the spirit lamp *d*. To the flanged base is attached, by soldering or brazing, a somewhat similar cylinder *k'* of greater diameter, forming a space between the two in which water is contained. The inner cylinder is fitted with a glass disc *m*, facing the flame of the lamp, and the outer cylinder *k'* is similarly fitted with a glass disc or bull's eye *n*, by which means the rays of light from the interior of the lamp pass through the water contained by these two cylinders to the exterior. The products of combustion are carried into the space filled with water through a sensitive valve *o*, fitted into the inner cylinder *k*, near the base, and pass outwards through a valve *p*, in the dome above the water level to the exterior of the lamp. The outer cylinder is fitted with a suitable handle, and has a cap *r*, which, when removed, exposes the valve *o*, in the inner cylinder, and facilitates its renewal, and the spherical oxygen reservoir *c* is fitted with a suitable connection *s*, by which is admitted a fresh charge of compressed oxygen

when the reservoir has been exhausted. A metallic ring *t*, attached to the globe, forms a base on which the lamp will stand, and when the lamp is used for submarine operations a weight is enclosed within this ring. By this means the buoyancy of the lamp is counterbalanced. In the more modern models a worm-and-screw motion is added to the valve *h*, so that the admission of oxygen may be regulated to the greatest nicety.

The oxygen can be supplied by the patentees in wrought-iron bottles, 6½ inches outside diameter, and 3 feet 3 inches long and ¼ inch thick, 16 hours supply tested up to 1,000 lbs. per inch, and filled with oxygen at about 600 lbs. to the inch for £5 5s. each, £4 10s. being for the vessel and 15s. for the oxygen; and the contents of these bottles can be conveyed to the lamp and breathing reservoir in less than a minute.

The following is a ready mode of providing oxygen if it has to be made at the place where the apparatus is used:—

Put a retort made of wrought-iron boiler plate, 18 inches high, 6 inches diameter, and ⅜ inch thick, and filled with five pints of chlorate of potassium and one gill of black oxide of manganese, on a slow smith's fire, and let the gas evolved pass through a cleaner (for which an old tin oil drum, 8 inches in diameter and 18 inches high, will serve), filled with water, into which a piece of caustic soda about the size of a walnut has been placed, so that the gas will pass through the water and be cleansed by the soda from any chlorine gas that may be with it.

The gas from this charge will fill four ordinary oxygen bags containing about 18 cubic feet, and will be more than sufficient to twice fill the reservoir for the breather and for the lamp; and from the bags the oxygen may be forced into the receivers by a pump, 1¼ inch diameter and 8 inches stroke, worked by hand, to a cylinder which is kept cool by a jacket through which a constant stream of cold water is kept flowing.

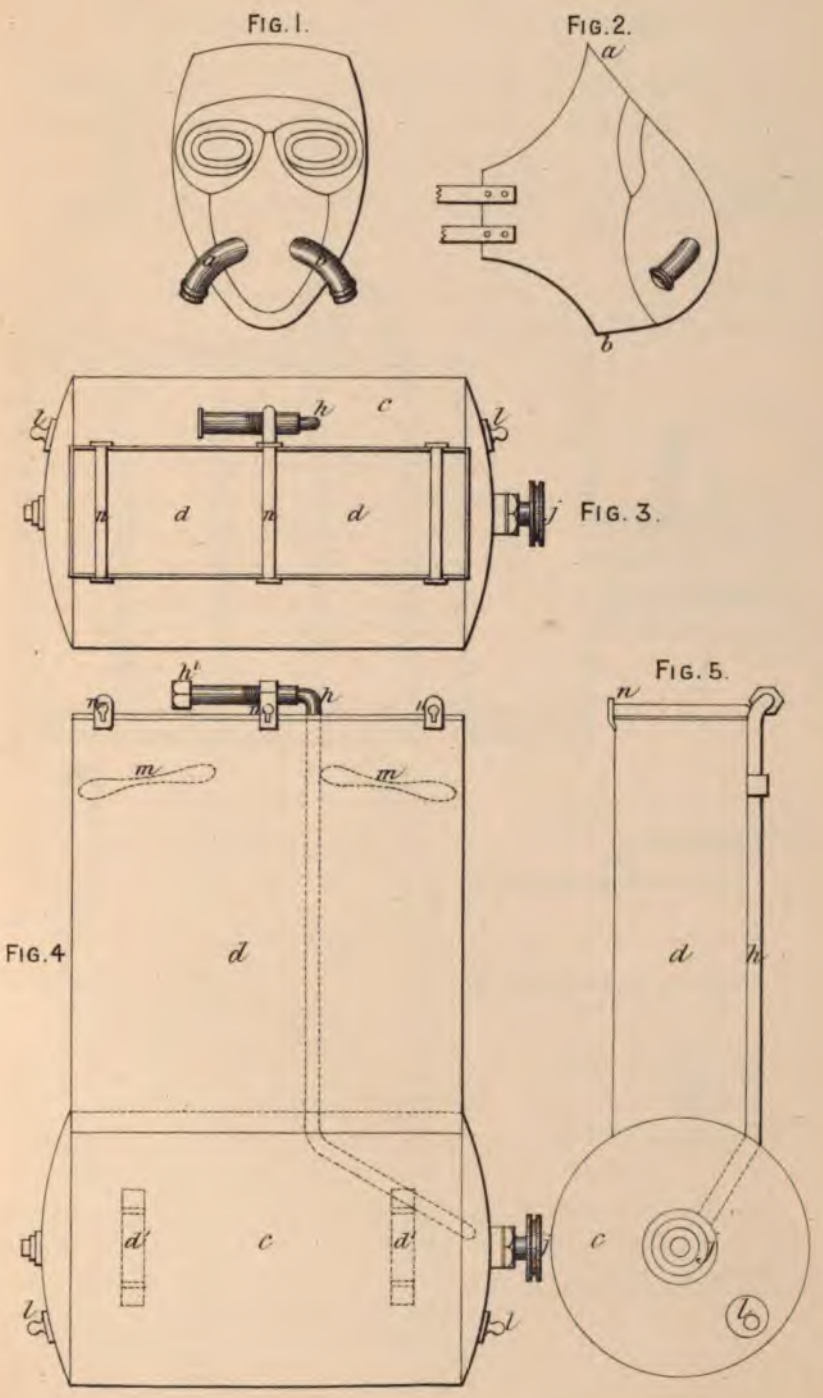
As time is always a great object when this apparatus is required, it may be useful to mention that in fifteen minutes from placing the retort on the fire, gas begins to come off, and in fifteen minutes more the bags are filled; after this it takes seven minutes to fill each reservoir to the required pressure.

If a man is well accustomed to the work, and has only to exert moderate energy, he can remain between three or four hours in unbreathable gases with one charge of oxygen; if the man has to exert himself violently, the supply will be exhausted much sooner; so also will it be if he is nervous or excited. Considerable experience is required to economise the oxygen, since the regulation of the supply is in the hands of the wearer, who, if he is not cautious, can rapidly exhaust it.

Mr. T. W. Bunning said, it might be interesting to know that the Steam Coal Trade had appointed a small committee to discuss the advisability of having an apparatus kept in a depôt, ready to be sent to any place at a moment's notice on receipt of a telegram; and they would be glad to receive any suggestion from Mr. Corbett or Mr. Hedley as to the best mode of conducting such a depôt, whether it would be better to make gas at the depôt or to bring it in jars from London.

Mr. S. H. Hedley, in answer to numerous questions upon the subject, said, that the apparatus was of great aid in exploring; but with regard to ridding, timbering, or anything of that nature, it could not be used very well, as it was rather cumbersome. For exploring it was very useful, and with it a person could travel in a height of about 3 feet 6 inches. He had used it himself after the Seaham explosion, and had travelled about 400 yards with its aid in the gas, in which distance he passed over two or three heavy falls. The height was about 4 feet for the first 100 yards and 6 feet for the remaining 300 yards. There was no work heavier than exploring to be done. It was not used in setting timber or any work of that description. It might be urged as an objection that the supply of oxygen is under the command of the wearer, who, if he gets at all nervous, might supply himself with too much, and so exhaust the store before it would be safe to do so; but this would be the only inconvenience, since an overdose of oxygen does not seem to have any injurious consequences, and if some regulator could be attached, which, when once set in motion would keep a continuous supply, it would be better. There seems also to be no inconvenience arising from the loss of the nitrogen through leakage, as enough to keep the fresh oxygen sufficiently diluted for respiration seems always to remain in the bag. At Killingworth, where the apparatus was used for the purpose of saving life, it was found that two men carried out a fainting man to a safe place while a third carried the lamps. With very little practice a man with common intelligence would be able to use the apparatus. There is no difficulty with regard to the mouth-piece if the lips are kept closed. If, by inadvertence, the mouth is opened, foul air is inhaled; by putting on the mask that difficulty is removed and the mouth can be kept open. The price of the breathing apparatus is about £20, and of the lamp about £14. On one occasion he had worn the apparatus three hours forty minutes without experiencing any difficulty either at the time or afterwards; but then he was either sitting still, or moving very little. If he had been undergoing any violent exertion he could not have worn it so long. With sufficient practice the noise, which gets less as the pressure decreases,

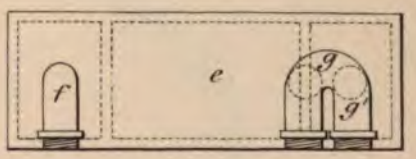
To illustrate the Secretary's paper "On the Fleuss Apparatus for breathing in noxious gases."



To illustrate the Secretary's paper "On the Fleuss Apparatus for breathing in noxious gases."

Fig. 6.

Fig. 9.



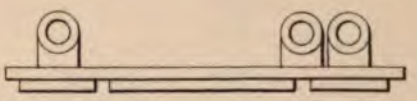
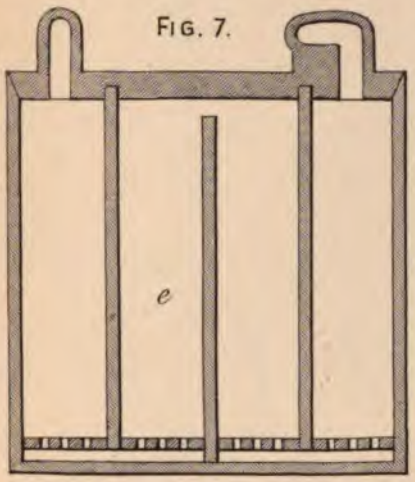


Fig. 7.



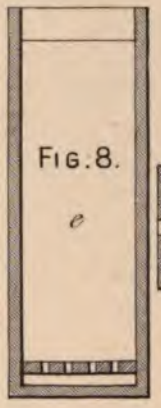


Fig. 8.

Fig. 13.

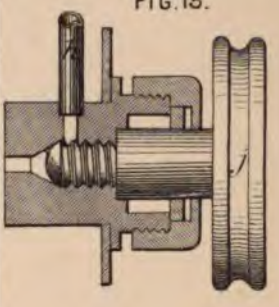


Fig. 10.

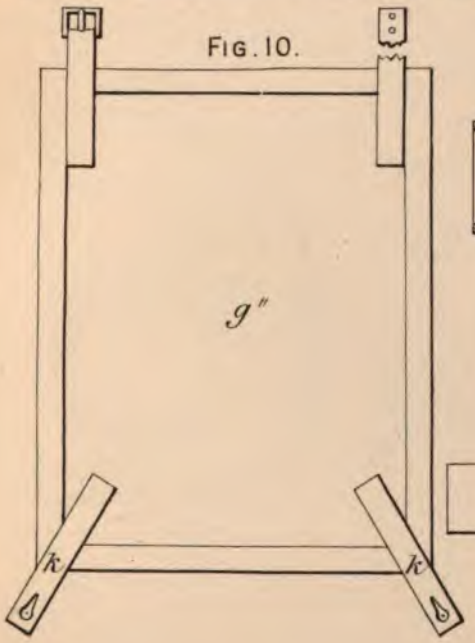


Fig. 12.

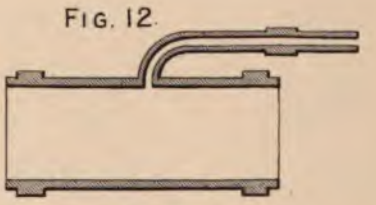


Fig. 12.

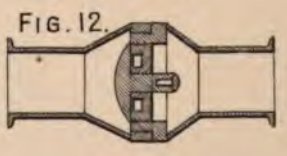
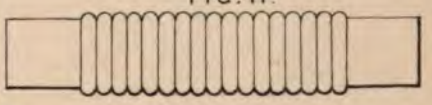


Fig. 11.



To illustrate the Secretary's paper "On the Fleuss Apparatus for breathing in noxious gases."

FIG. 14.

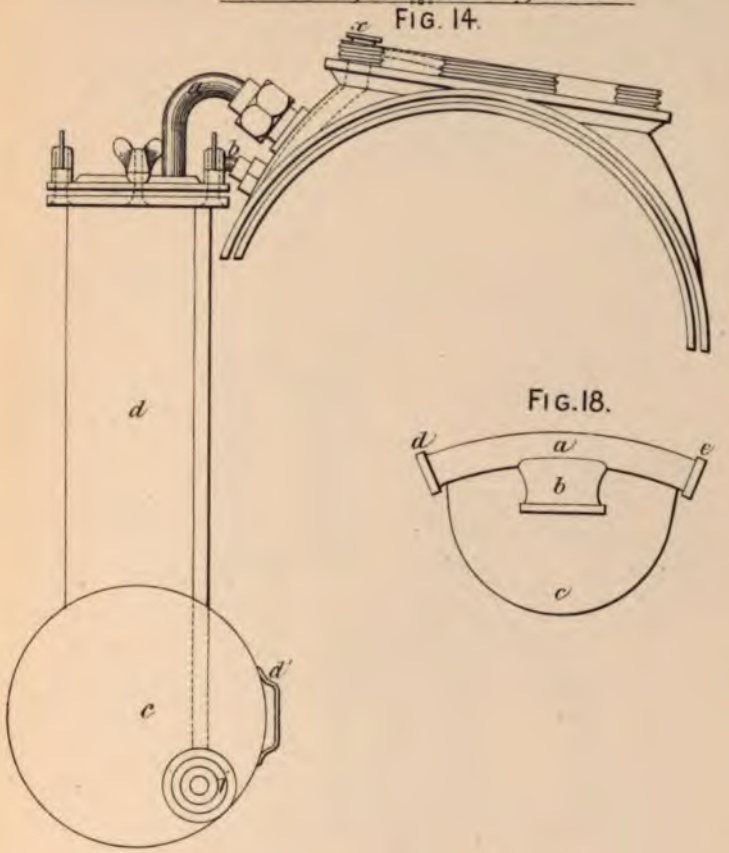


FIG. 18.

FIG. 15.

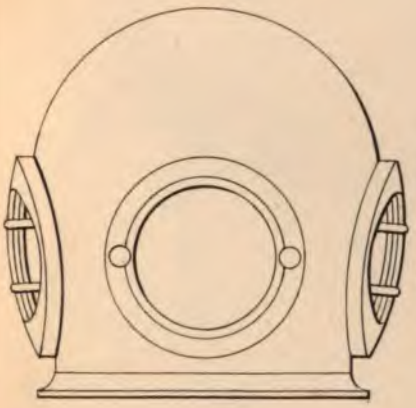


FIG. 16.

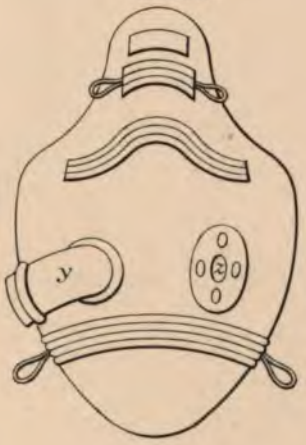
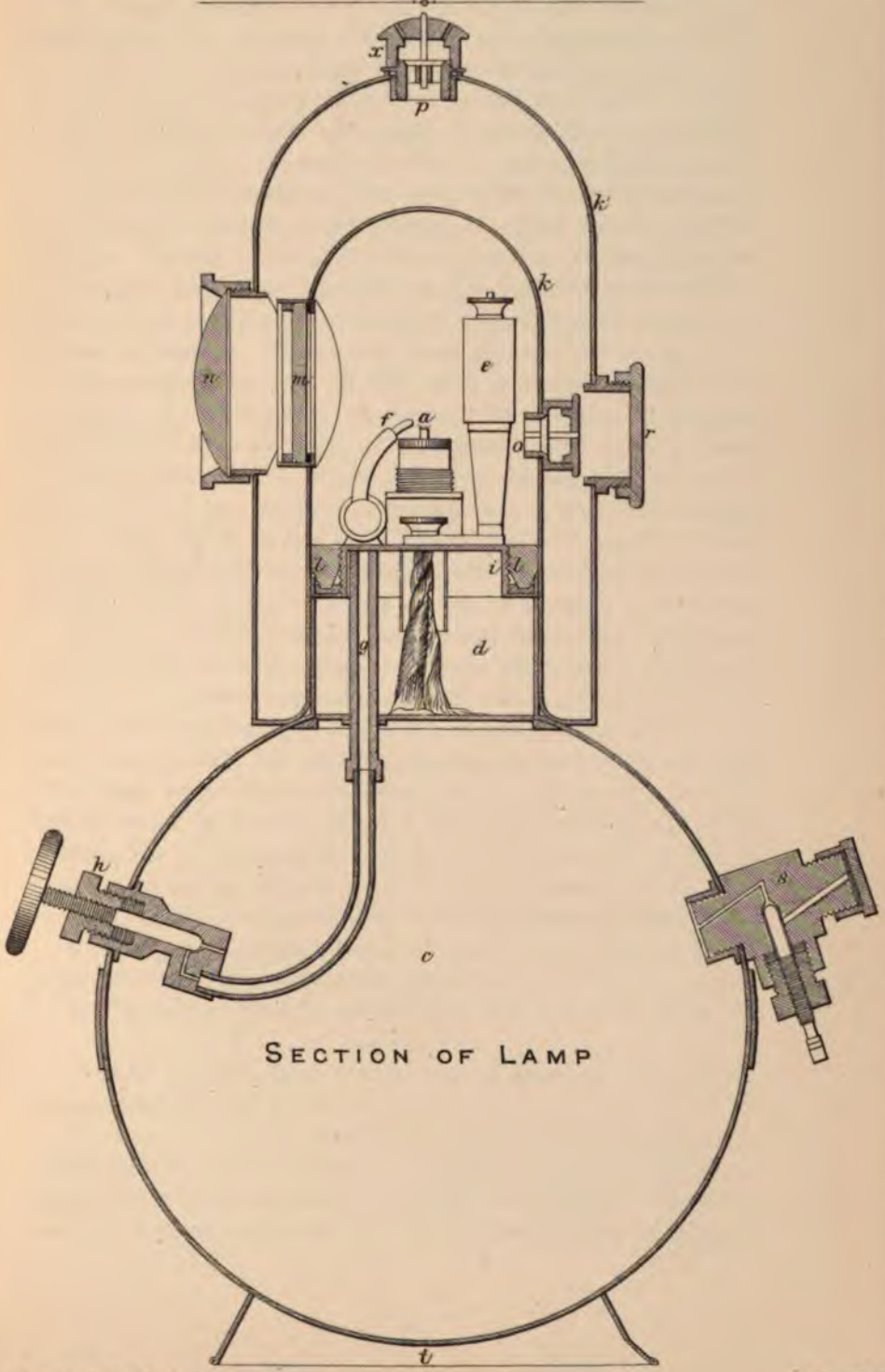


FIG. 17.

To illustrate the Secretary's paper "On the Fleuss Apparatus for breathing in noxious gases."



SECTION OF LAMP

of the oxygen passing into the bag, will always give warning of the supply getting low; of course it is advisable not to go in so far as to run the smallest chance of the supply failing, and it would probably be safer if a small pressure gauge were attached, but this would add a pound or two to the apparatus which now weighs 28 pounds, as much as can be carried with comfort; at present the time the apparatus has been in use, and the sound of the discharge of the oxygen from the receiver to the bag, are the surest indications of the quantity of oxygen remaining in the reservoir. The bag into which the fresh oxygen is at first poured expands and prevents the pressure becoming too great for being comfortably inspired, and the art of supplying the oxygen by regulating the screw is only acquired by practice. When a man enters the mine with the apparatus on, he proceeds as far as he can with safety or comfort to himself without putting the apparatus to his mouth. To save time in changing the breathing apparatus, bottles of compressed oxygen could be placed at a point where the air is just becoming vitiated with deleterious gases, and thus save the time in sending them to bank to be changed. There should never be less than three people down together in the dangerous gases, and they should all withdraw as soon as one got into difficulty. There should be at least six sets of apparatus in any depôt for the use of a district, and such depôt should be provided with means both for making and compressing the oxygen as well as having a large store of oxygen in bottles already compressed. The lamp will burn about four hours; but, if the supply of oxygen is accidentally turned off, the spirit lamp ceases to burn and the light goes out; the same result will occur if too much oxygen is directed through the flame of the wick, or, if the lime is broken by a sudden shock from the lamp striking any object severely. In all these cases it would have to be uncovered to be lighted again; and, therefore, brought out of the deleterious gases. Of course the regulator requires altering with great care as the pressure diminishes.

The CHAIRMAN proposed a vote of thanks to Mr. Bunning for his paper and to Mr. Hedley for the information he had given on the subject.

Mr. BEWICK seconded the motion, which was unanimously agreed to.

Professor LEBOUR'S paper "On the Mineral Resources of the Country between Rothbury and Wooler:—

Professor LEBOUR said, he did not suppose there would be much discussion upon this paper. When it was read there was a possibility of the Central Northumberland Railway being made from Newcastle to Rothbury, and from Rothbury to Wooler; but that possibility was now considerably

lessened, so that a great many of the resources lying to the west of Rothbury would probably remain boxed and bottled up in the earth for some years to come. When the railway was made he had no doubt that these resources, especially the cement beds, would become as valuable as the Scotch cement beds, which they resembled in quality and surpassed in thickness.

Mr. BEWICK said, that he had had the opportunity of going over the district described by Professor Lebour, and from what he saw it did not seem to be overflowing with milk and honey. The district struck him as being rather an agricultural than a mining one. Although the Central Northumberland Railway Company had not succeeded in getting an Act of Parliament, or rather had withdrawn their application, there remained the fact that the North-Eastern Company got an act enabling them to open up the country from a few miles south of Wooler to Cornhill, and the only part of the country untraversed would be the part between Rothbury and Eglingham. When the Central Northumberland Railway was before the Committee of the House of Commons, the Committee recommended that that district should be opened out, and then the treasures described by Professor Lebour might be utilized.

Professor LEBOUR's paper "On the Present State of our Knowledge of Underground Temperature:"—

Professor LEBOUR asked the members to make a correction in his paper (page 70). Where it stated that "the decrease of temperature upwards is about three and a-half times *more* rapid in the air than in the rock," it should be "*less* rapid." When the paper was read Mr. Boyd asked him to give the height above the sea level of each of the places mentioned in Table I., and Mr. Bewick asked him to give the geological formation of each. He promised, inadvertently at the time, to do those two things, but some of the places were in North Siberia, and he did not know their height above the sea, nor where to get the information; but the geological formations he would give. Since the paper was read many observations of a remarkably interesting nature had been made in Alpine tunnels. A new formula for calculating the temperature at any depth below mountains and so on, had been arrived at by Mr. Lommel and Professor Stur. Taking all these circumstances together, he thought it would be more satisfactory to read a short supplemental paper than to give, in discussion, the geological formation of the places.

Mr. BEWICK suggested that Professor Lebour, in his second paper, might give information about the temperature in the Channel tunnel.

Professor LEBOUR said, the request he made at the end of his paper, for information as to observations under the sea, had been met in the most kind manner by the mining engineers to whom the paper was addressed. An interesting set of observations had been taken in the Whitehaven Coal-field with the thermometers of the Committee; and Mr. G. Baker Forster had consented to have observations taken in the mines in Northumberland working under the sea in his charge, and there would then be no lack of information from both sides of the island. One point which he thought would have given rise to discussion was the extraordinary length of time boreholes retained heat from boring instruments. Observations which had been taken several months after boring operations had been vitiated by the residuum of heat, and it would be unwise to take observations in boreholes by means of thermometers until sufficient time had elapsed for the heat to be dissipated.

Mr. CHARLES PARKIN'S paper "On Jet Mining."—The SECRETARY read the following letter from Mr. Parkin:—

HUTTON-LE-HOLE,
JUNE 7TH, 1882.

THEO. WOOD BUNNING, ESQ.

MY DEAR SIR,—I am sorry that an important engagement will prevent my attending the meeting on Saturday.

When I read my paper "on Jet Mining" in December last, in the discussion which followed, Professor Lebour considered Professor Phillips' view, "that jet was simply a coniferous wood," to be wrong. How do we then account for the petrified stump of a tree, found near Haiburn Wyke by Young and Bird in their survey (see quotations in my paper), consisting of the root of coaly jet in a bed of shale, whilst the trunk in the sandstone was partly of petrified, and partly of decayed sooty wood? I may add a similar occurrence was met with at Rosedale.

Since reading my paper an article has appeared in Cassell's Magazine, February number, on the subject, in which rather a curious statement is made. In speaking of the recent expansion in the trade, it goes on to say "that the introduction of steam power, &c., and the increasing use of jet bracelets, *worn as a preventative of rheumatism in the arms*, have given recent expansion to the trade." The use of jet *as a preventative of rheumatism* is quite new to me, and I should be glad to learn whether the virtue is a characteristic of jet alone, or whether a bracelet of any other material would prove equally beneficial? I would take this opportunity of expressing my thanks to Professor Lebour for having added so much to the interest of my paper at the meeting, by illustrating the subject with his fine collection of specimens.

I am, my dear Sir,
Faithfully yours,
CHARLES PARKIN.

Professor LEBOUR said, he had never heard of jet as a cure for rheumatism; but there were a great number of stones—he could make a list of 50 or 60—worn uselessly, or not, for medicinal purposes. As to Phillips' observations on jet, he (Professor Lebour) said he thought Phillips had gone too far in saying that all jet exhibited woody texture. There was no doubt that a great quantity of jet showed no texture of any kind. He thought Phillips had founded his statement on the sections he had seen; but the art of making sections had considerably improved since Professor Phillips' time, when if a man had had one or two sections cut they would be considered interesting and rare by him, and no doubt that gentleman might have seen one or two sections of fossil trees which had become mineralogically jet; but the greater part of the jet he (Professor Lebour) had seen possessed no kind of structure visible to the naked eye, or even under high microscopic power. He adhered to the remark which he made when the paper was read, explaining it in this way, and it was not in contradiction of what Phillips said. What Philips said, instead of applying to all jet, probably applies to only some jet.

PROCEEDINGS.

THURSDAY, JUNE 22ND, 1882.

EXCURSION TO THE LANGLEY BARONY LEAD MINES.

At the invitation of Messrs. Bewick and Partners, the proprietors, a party of about forty members of the Institute visited the above mines on Thursday, the 22nd June, 1882. Conveyances had been provided by the Firm, and the party first inspected the Joicey Shaft and works connected therewith, and afterwards proceeded to the Leadbitter Shaft and to the Honeycrook Works.

At the conclusion of the inspection the members were invited to take luncheon with the owners at Mr. Bewick's residence, the extremely wet state of the weather preventing any of the party proceeding to the Byron Colliery to inspect Messrs. Bowlker and Watson's Fan, as was originally intended.

Mr. Bewick kindly promised to furnish a full description of the method of getting and preparing the lead ore, and of the machinery used for the purpose, for publication in the Transactions.

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 5TH, 1882, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEO. BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

MESSRS. A. L. Steavenson, T. W. Benson, and A. M. Potter, were appointed scrutineers to examine the voting papers for the election of officers for the year 1882–83.

The SECRETARY read the minutes of the previous meeting and reported the proceedings of the Council.

The SECRETARY also read the reports of the Council and Finance Committee, which were unanimously adopted.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBER—

Mr. GEORGE HENRY OLDHAM, M. and M.E., St. John D'el Rey Mining Company, Tower Chambers, Finsbury Pavement, London.

ASSOCIATE—

Mr. THOMAS HENRY WARD, Manager, Kuldiha Colliery, Bengal, India.

STUDENT—

Mr. FRANK MARSTON, Bromfield Hall, Mold.

The following were nominated for election at the next meeting:—

ASSOCIATES—

Mr. JOSEPH PROUD, South Hetton Colliery Offices, Sunderland.
Mr. GEORGE BENSON MONKHOUSE, Accountant, Newcastle-on-Tyne.
Mr. W. R. DAKERS, Chilton Colliery, Ferryhill.

STUDENT—

Mr. COLLIN COLE, Bebside Colliery, Northumberland.

Mr. J. D. KENDALL, C.E., F.G.S., read the following paper "On the Hæmatite Deposits of Furness:"—

THE HÆMATITE DEPOSITS OF FURNESS.

By J. D. KENDALL, C.E., F.G.S.

PART I.—INTRODUCTORY.

Furness may be considered as a continuation of the district dealt with by the author in his paper on the "Hæmatite Deposits of West Cumberland," published in Volume XXVIII. of the Transactions. Together, these two districts yield the principal part of the hæmatite produced in Great Britain. Furness and West Cumberland being so near together it might be expected that the deposits they respectively contain would have many points of correspondence, and such is the case; but at the same time—and this is perhaps the more interesting fact—there are many points of difference in the deposits of the two areas. By way of bringing together the more prominent facts relating to the deposits of the two districts, so that they may be seen on the same field of view, and a more comprehensive judgment formed thereby, it is proposed, in the course of the paper, to notice the more important of these variations and agreements, and, if possible, to explain them. Properly, the deposits now to be considered should have been included in the previous paper above alluded to.

Furness is divided into two parts, High Furness and Low Furness. The boundary between these two divisions is, however, not very clearly defined. The former includes the high ground northward from Ulverstone as far as the head of Windermere, and for several miles on both sides of Coniston Lake. It is in fact a part of the Lake Country. Low Furness, as its name indicates, consists mainly of low lying ground, which seldom reaches an altitude of 300 feet and is mostly below the 250 feet contour. It is in this part of the district that hæmatite occurs in such large quantities. The low lying ground in which it is found is a continuation of the long, narrow belt in West Cumberland which lies between the sea and the western hills of the Lake Country, the only difference between the

low ground in West Cumberland and this being, that there the hills are on the east of the low ground whilst here they are on the north; so that in both districts there is a stretch of low lying and gently undulating ground, with the sea on one side of it and rough mountainous ground on the other side.

The geological systems represented here are the same as in West Cumberland, although they are differently developed in the two areas. The relations of the different formations occurring both here and in the adjoining country are shown in Plate XXXVII. On a larger scale the superficial extent of the various rocks found in the district immediately under consideration, is given in Plate XXXVIII. The comparative depth and the succession of those rocks are given in Plate XXXIX. As will be seen from this section there are two breaks in the geological continuity, as is the case in West Cumberland, and they occur at the same points in both districts. One break being between the Silurians and the Carboniferous rocks, the other between the Carboniferous rocks and the Permians. Throughout each of the latter systems there seems to be perfect conformity. Figs. 1 and 2, Plate XL., are sections across the district (Plate XXXVIII.), and will explain its geological structure more clearly.

Skiddaw Slate.—A patch of this rock appears in the district in a most remarkable manner, as shown in Plates XXXVII. and XXXVIII. It has been thrust up through the overlying Silurians in such a way that it may now be seen on the surface side by side with the Coniston Limestone of Haume, which, geologically, is many thousands of feet above the Skiddaw Slate. Relatively this upheaval is greater even than that which has occurred at Black Comb, where the same kind of rocks have for a comparatively small area been forced up through the greater part of the Borrowdale series.

As seen in this district the Skiddaw Slate presents a very shaley appearance, breaking up, under the influence of the weather, into small thin flakes.

Borrowdale Series.—A small patch of these rocks occurs on the north side of the Skiddaw Slate area, as shown in Plate XXXVIII., but there is nothing about them which demands special notice in this paper.

Coniston Series.—These rocks, as developed in this district, have their normal character, and they do not need special mention.

Carboniferous Rocks.—This series of rocks, consisting of the subdivisions described below, rest unconformably on the Silurians just noticed. At the time the Carboniferous rocks were deposited the main

outlines of the Silurian hills of Furness and neighbourhood seem to have been very much what they are to-day. This is shown by the way in which the Carboniferous rocks run up into main valleys like the Duddon and Leven, as may be seen in Plate XXXVII.

1.—*Conglomerate.*—This rock occupies a very small area on the surface, as shown on Plate XXXVIII. Its limited extent appears to be owing to the way in which it, along with the other rocks of the Carboniferous system, were thrown down at the foot of the Silurian hills. Every additional layer put on would overlap, on the landward side, that below, so that only after the rocks had been tilted and very considerably denuded could the lowest layers possibly be brought to the surface.

The formation consists of rounded fragments of older rocks firmly cemented together in such a way that it has the appearance of a hardened boulder clay. It was at one time supposed to belong to the Devonians.

2.—*Shales and Limestones*—Overlying the conglomerate there is a great thickness of shale with numerous thin bands of limestone. The latter increase in thickness toward the upper part of the formation and gradually introduce the great mass of limestone by which they are overlaid. The following is the journal of a borehole put down through these rocks between Dunnerholm and Ireleth:—

	Fms.	Ft.	In.
Sand clay and pinnel ...	29	4	6
Hard limestone		4	8
Red limey shale		1	2
Limestone		2	0
Red limey shale		2	3
Limestone		1	6
Red limey shale	1	2	6
Limestone		1	11
Red limey shale		3	0
Limestone		5	5
Red limey shale		1	3
Brown limestone		2	6
Red limey shale	1	0	3
Brown limestone	1	1	5
Hard limey shale		1	3
Brown limestone		1	3
Hard sandy limey shale ...	1	0	2
Brown limestone			5
Hard sandy limey shale ...		5	8
Hard bastard limestone ...		3	9
Carried forward ...	40	4	10

	Fms.	Ft.	In.
Brought forward ...	40	4	10
Red limey shale		3	6
Hard bastard limestone ...		1	0
Red limey shale	2	1	6
Bastard limestone	1	0	3
Red limey shale			6
Bastard limestone		1	4
Red limey shale		3	9
Bastard limestone		1	6
Red limey shale			8
Bastard limestone		1	3
Red limey shale	1	2	0
Bastard limestone		2	11
Red limey shale		2	0
Bastard limestone		1	0
Red limey shale		1	0
White limestone			4
Red limey shale			10
White limestone			4
Red limey shale			8
Carried forward ...	49	1	2

	Fms.	Ft.	In.
Brought forward ...	49	1	2
Red limestone		4	8
Limey shale		1	7
Red limestone			6
Limey shale		1	6
Hard limestone		3	5
Red limey shale		4	6
Hard limestone		2	0
Red limey shale		5	6
Hard limestone			9
Red limey shale		2	0
Hard limestone		2	0
Red limey shale		1	0
Hard limestone		1	0
Red limey shale			9
Hard limestone			3
Red limey shale		1	9
Hard limestone		1	1
Red limey shale		1	9
Hard limestone			9
Red limey shale		4	6
Hard limestone			11
Red limey shale		2	1
Hard limestone		1	9
Red limey shale		1	6
Hard limestone			11
Red limey shale			10
Hard limestone ...		3	11
Red limey shale	2	1	6
Hard limestone		5	8
Red limey shale	1	0	2
Hard limestone		1	8
Red limey shale	2	1	7
Limestone			8
Red limey shale	1	4	3
Limestone			8
Red limey shale		2	9
Limestone			3
Red limey shale		5	3
Carried forward ...	68	0	9

	Fms.	Ft.	In.
Brought forward ...	68	0	9
Limestone		1	0
Red limey shale	1	2	0
Hard limestone		2	1
Red limey shale		2	0
Hard limestone		1	8
Red limey shale		4	3
Hard limestone		1	9
Red limey shale		2	8
Hard limestone		1	9
Red limey shale	1	1	0
Red limestone			9
Red limey shale		1	7
Red limestone			6
Red limey shale		1	0
Red limestone		1	6
Red limey shale	1	4	8
Soft red and white parting...		3	1
Hard red shale		1	5
Hard red limestone		3	2
Red limey shale		4	7
Red limestone			9
Red limey shale	9	5	1
Bastard limestone	1	3	9
Red limey shale	2	3	10
Red shale	5	5	4
Red bastard limestone ...	1	1	11
Red shale	2	1	9
Red bastard limestone ...	1	0	6
Red shale	1	4	10
Red bastard limestone ...		5	9
Red shale	2	4	5
Bastard limestone		3	11
Red shale	1	4	3
Bastard limestone			9
Red shale	5	5	6
Bastard limestone			6
Red shale	2	0	10
Total depth... ...	119	0	10

3.—*Carboniferous Limestone.*—As in West Cumberland so in Furness, this is the most important formation of all, so far as the present subject is concerned, as it is in this that all the hæmatite deposits occur. It

consists almost entirely of limestone, there being only in addition a few thin beds of shale which seldom exceed an inch or two in thickness. The thickest beds of shale occur near the bottom and top, that is near the underlying shales just noticed and the overlying Yoredales, presently to be described. The total thickness of the formation is not known, but it is certainly over 940 feet, as that thickness has been pierced by one borehole at Windhills, near Stainton. The following is a journal of that hole :—

	Fms.	Ft.	In.
Surface	5	1	0
YORDEDALE ROCKS.			
Blue whirlstone		5	6
Grey sandstone		5	0
Blue shale	6	3	0
Grey sandstone		3	0
Blue shale	8	0	0
White sandstone		2	0
Black shale	1	3	6
Shale and sandstone ...	2	0	0
Sandstone	2	3	0
Black shale	1	2	0
Sandstone	1	4	0
Black shale	29	2	6
Shale and sandstone ...		5	6
Black shale	40	4	6
Bastard limestone	1	4	6
Black shale	2	1	4
Grey limestone		3	2
Black shale	2	0	6
Limestone	1	0	6
Black shale	1	3	0
Fossil shale	5	4	6
Grey limestone		2	0
Bastard limestone		4	0
Shale and limestone... ...	1	4	0
Black shale	4	0	0
Limestone	2	2	0
Black shale	1	3	0
Red joint			6
Limestone			6
Black shale...	1	1	0
Carried forward ...	129	1	0

	Fms.	Ft.	In.
Brought forward ...	129	1	0
CARBONIFEROUS LIMESTONE.			
Brown limestone		3	6
Limestone	1	0	6
Black shale		1	0
Lough hole		1	0
Bastard limestone		5	6
Shale and limestone... ...		5	6
Shale and limestone... ...		4	0
Limestone		3	0
Shale (fossil)		5	6
Limestone	5	2	2
Shale (fossil)	1	4	4
Limestone		5	0
Grey sandstone		2	0
Shale	1	2	6
Black shale		5	0
Shale and limestone... ...		3	0
Ore and limestone		3	0
Grey limestone	3	3	9
Limestone mixed with white clay	2	1	0
Grey limestone	3	3	6
Light grey limestone ...	41	2	3
Clay mixed with ore ...		2	8
Dark grey limestone, streaks of ore		5	0
Limestone	66	0	11
Grey limestone marked with brown joints		2	11
Limestone	21	4	0
Total depth... ...	286	5	6

There being no beds of marked lithological character in the formation it is impossible to arrive at the thickness by correlation. The same difficulty is met with in fixing the exact geological level of many of the

hæmatite deposits. It is easy to show that the Askam deposit is in the lower beds of the formation, and that the Stank and Stainton deposits are in the upper beds, but it is not possible at present to say in which beds the Lindal Cote deposit is, except that it is in the middle beds, but whether it is nearer the top or bottom cannot be said, and there are many cases of this kind in the district. Equally difficult is it to trace in these rocks the existence of faults for the same reason. It is sometimes possible to detect them in the mine, but the amount of their throw cannot even then be determined, as will be readily understood.

As in the Whitehaven district so it is found to be here, the *absolute* level of a deposit is altogether independent of its *geological* level, some deposits in the bottom beds of limestone being much shallower or nearer the surface than others that are in the upper beds of limestone.

The dip of the rocks in the western part of the district is to the west, at angles varying from 20 to 45 degrees. In the eastern part of the district the general dip is to the S.E., at angles of 5 to 15 degrees.

In searching for hæmatite in Furness some very peculiar sections are occasionally met with. That given below may be taken as an example:—

Journal of a Borehole put down at Crossgates.

	Ft.	In.	Ft.	In.
Soil	2	0		
Gravel and clay	24	0		
Decomposed limestone	17	0		
			43	0
Yellow clay mixed with iron ore	4	0		
Black mould	4	0		
Iron ore (dark coloured)	2	0		
Black mould mixed with iron ore	6	0		
			16	0
Iron ore	8	0		
Decomposed limestone	7	0		
			15	0
Black woody deposit			12	0
Decomposed limestone			6	0
Black mould and wood	2	0		
Yellow clay mixed with ore	16	0		
Black mould mixed with ore	10	0		
Do.	4	0		
Do. mixed with ore and limestone	3	0		
			35	0
Total depth			127	0

The wood found in this and similar sections is exogenous, and belongs to recent species which proves clearly that it at any rate, and

presumably the material in which it is embedded, has been recently introduced. The three masses of clay and black mould mixed with iron ore in the above section may therefore be taken to be filled "loughs" or caverns. Many of the caverns found in the district contain a large quantity of clay, and also pieces of hæmatite and other materials. If they were *filled* with these materials a section of them would not be very different from that of the borehole given above.

The "backs" or vertical joints in the limestone have the following directions, one set bearing about 25 degrees north-west and south-east, the other set being nearly east and west; and it is worthy of mention that all the caverns in the district have one or other of these directions where they are not interfered with by faults. The large cavern which was discovered at Stainton about eleven years ago illustrates this observation very well. The length of that cave is about 230 yards, and although it makes numerous turns in the course of its length, it invariably follows one or other of the two sets of joints in the limestone, as is easily ascertained, for these joints can be seen quite distinctly in the roof of the cavern. A plan and section of this cavern is given in Plate XLI.

The composition of the limestone is variable, sometimes being very silicious, much more so than in Analysis No. 3 below. Where it has been worked for fluxing purposes it is very pure, as shown in Analyses Nos. 1 and 2 :—

	1. Stainton.	2. Goldmire.	3. Haume.
Carbonate of lime	95·00 ...	98·00 ...	89·00
Do. magnesia	4·20 ...	·70 ...	2·93
Silica	·50 ...	·83 ...	3·24
Oxide of iron and alumina Carbonate do.	·30 ...	·68 ...	2·60
	100·00	100·21	97·77

The specific gravity may be taken to be about 2·72 on an average.

4.—*Yoredale Rocks.*—Overlying the limestone just described, and terminating the Carboniferous system upwards, there is a large mass of dark-coloured shales interbedded in their lower part with one or two beds of limestone, and near the top with a few beds of sandstone. These rocks were formerly supposed to belong to the Coal-measures—in fact a few years ago a shaft was sunk near Stank in the hope of finding coal. This shaft, after passing through about 90 fathoms of rocks belonging to the Yoredales, came upon a very fine deposit of hæmatite in the Carboniferous limestone below. The greatest thickness of Yoredale

rocks yet proved was near Gleaston, where, by the Diamond boring machine, about 1,410 feet were pierced after passing through about 590 feet of St. Bees Sandstone and shales and 65 feet of Magnesian Limestone. The upper part of the Windhills borehole, given on page 215, was in these rocks, and it may be taken as a fairly representative section of them. Near Gleaston there is a small patch of greenstone protruding through these rocks. What was probably a branch from it was passed through in the midst of the Yoredale rocks by the deep borehole just alluded to. The deep borehole at Rampside also pierced a similar rock in the Red Sandstone.

Before leaving the Carboniferous rocks it may be of use, and at the same time interesting, to notice how differently they are developed here from what they are in the Whitehaven district. For this purpose Plate XLII. has been prepared. Sections A, B, and C are taken respectively in Furness, at Cleator Moor, and near Cockermouth. The change from the Cleator Moor Section to the Cockermouth Section occurs at the Silurian promontory of Ullock, whence the proportion of sandstone and shale seem to gradually increase, through by Cockermouth and Caldbeck on to Alston Moor, where these silicious and aluminous rocks occupy by far the greater part of the formation, the limestone being only about one-fourth of the whole. The change from the Cleator Moor Section to the Furness Section is made somewhere in the concealed area between Egremont and Silecroft. From the latter place, where the Carboniferous Limestone first comes to the surface after leaving Egremont eastward across Furness, it assumes the same massive character, and has the same freedom from shales and sandstone which it has in Derbyshire.

Magnesian Limestone and St. Bees Sandstone.—Both these rocks are represented in Furness, the latter in considerable force, but it is not necessary to notice them at any length, as they seem to have no connection with the subject under discussion. Pieces of Red Sandstone belonging to the St. Bees Formation are found in some of the deposits, but they seem to have been introduced subsequently to the formation of the deposits, as will appear further on. By a borehole put down near Rampside, in search of coal, the Red Sandstone, with the accompanying gypseous shales, were proved to be more than 1,230 feet thick.

Superficial Deposits.—These consist of boulder clay, sand, and gravel. Sometimes, as at Yarlside, they are as much as 537 feet thick; among the included pebbles and boulders, hæmatite frequently occurs, but the boulders of this ore have no necessary connection, as is often supposed, with underlying deposits of it. They are, for instance, very frequently found

over the Red Sandstone, and also over the Yoredale shales. Associated with this superficial formation there is a curious brecciated limestone which is known locally as "Crab rock," and which was supposed by Murchison and Harkness to belong to the Permians, and to be the equivalent of the Eden Valley "Bockram." It was also considered by them to show the Permian age of the hæmatite.

In leaving this part of the subject, it may be well to notice that the physical changes undergone by this district correspond very closely with those that have affected West Cumberland. Both districts are, in fact, parts of a much larger area over which there has been a corresponding sequence of events. The rocks which occupy the lower ground immediately surrounding the mountainous tract of the Lake Country, seem to have been everywhere similarly affected. The Carboniferous rocks rest on the upturned and eroded Silurians, and the Permians are spread out unconformably over the Carboniferous rocks. There thus appears to have been three great upheavals of the Lake District rocks, the first of which took place in pre-Carboniferous times, the second in pre-Permian times, and the third and last subsequently to the deposition of the Permian Rocks.

PART II.—FORM, POSITION, AND INNER NATURE OF DEPOSITS.

FORM AND POSITION OF DEPOSITS.—In describing the deposits in the Carboniferous limestone of West Cumberland they were divided into four kinds:—1st, "Bed-like" deposits; 2nd, "Vein-like;" 3rd, Dish-like;" and 4th, "Irregular-shaped" deposits. In Furness they may be separated into three kinds:—1st, "Vein-like;" 2nd, "Dish-like;" and 3rd, "Irregular-shaped." So far as the author is aware, there is not a single "bed-like" deposit in this district, unless the small flats from the Lindal Moor and Stank Veins, hereinafter to be noticed, be considered such.

This absence of "bed-like" deposits is curious, and evidently arises from the fact that the limestone occurs almost in one solid mass, and is not separated by intervening layers of sandstone and shale, into beds, as at Whitehaven. The rocks here being everywhere of the same character, there is nothing which could induce a "bed-like" form of deposit.

1.—*Vein-like Deposits.*—Some of the most important deposits in the district are of this form—that at Lindal Moor being the finest. The length of that deposit, so far as it has been worked, is about 1,000 yards in a direction about N. 25 degrees W., and S. 25 degrees E. Its breadth is very variable, sometimes being only a few inches wide, whilst at other places it is over

30 yards. Plate XLIII. is a section across the northern end of the vein, at a point where the width was more regular. From that section it will be seen that the deposit is laid alongside a fault, in fact three faults are seen, but whether they continue alongside the deposit from N. to S. cannot be said, as the lying cheek or "foot-wall," as the rocks on the upside of the fault are called, has not been sufficiently laid open at the southern end of the deposit, but the ore at that end of it seems to lie on the most westerly of the three faults shown in the above section. The foot-wall of the vein is very regular, as shown in the section, and the varying width of the ore just noticed is entirely due to the irregular form of the "hanging-wall" as the rocks are called on that side of the vein opposite the "foot-wall." At the northern end of the vein the ore has been worked to a depth of nearly 60 fathoms, and the bottom of it seems to have been reached. In the southern end it is now being worked at 70 fathoms, and ore is still going down in the sole of the lowest workings.

Another "vein-like" deposit of some importance is being worked by the Stank Mines and by some of the pits of the Yarlside Mining Company. This deposit was found by the Barrow Steel Company when they were searching for coal in the Yoredale rocks, near Stank. A section of the northern end of it is given in Fig. 1, Plate XLIV. Here, too, the ore occurs by the side of a fault, but in this case it is in the rocks on the upside, whereas at Lindal Moor it is in the rocks on the downside of the fault. As shown in the section, there is, near the upper part of the vein, a "flat" of ore, but so far as yet proved it is not of great extent. This "flat" is the only approach to a bed-like deposit that has come under the writer's notice in Furness, and the only one so far as he knows that has been found there. The direction of the vein is about 25 degrees N.W. and S.E. It has been worked for a length of about 600 yards, and for a depth of about 30 yards without reaching the bottom. The width varies from a few inches to about 25 yards including the masses of limestone which are embedded in the ore. Occasionally these limestone masses are so large, and so elongated in the direction of the vein, that the ore is in places split up into a number of vein-like bodies which are parallel to one another in the main, but, being of irregular breadth, communicate at intervals and form a sort of net-work of ore in the limestone. The "hanging" wall is quite regular, and the variations in the width of the vein are due to the irregular form of the "lying cheek." This is just the opposite of what is seen at Lindal Moor, but the two deposits correspond in this, that the regular side of the vein in each case is

that on which the fault is situated. The limestone at Stank is overlaid by Yoredale shales which dip in a south-easterly direction, that is, along the vein. The ore is confined entirely to the limestone, and does not go up into the shales, so that the vein may be said to have a dip south-eastward corresponding to that of the surrounding strata. It has thus two dips, one westward, due to the inclination of the fault by the side of which it is laid, the other south-eastward like the adjoining limestone. This longitudinal dip of the ore and the accompanying increase in the thickness of the overlying shales are such that at the most southerly point worked, the upper part of the vein is at a depth of about 80 fathoms from the surface, whilst near the Yarlside Mines the same ore is reached at a depth of about 40 fathoms. The vein seems to be best at the rise end and to become poorer as it is followed in below the shales. This feature is often seen in similar deposits in the Whitehaven district.

Another vein-like deposit is shown in Fig. 2, Plate XLIV., which is a cross section of part of the Yarlside Mines. Its direction is about north-east and south-west, corresponding with that of the fault along which it is laid. Ore has been worked here to a depth of 42 fathoms from the surface without reaching the bottom. As in the two deposits just described, its width is exceedingly variable. Sometimes the ore is found close against the fault, at another time there is a piece of silicious stone between them as shown in the section.

In all the vein-like deposits hitherto found, notwithstanding the great variations in their width, there is a general narrowing downwards. This is partly shown in Plate XLIII., but in some sections it is much more evident than in that one.

All the vein-like deposits are in what may be called the eastern side of the district, or on the east side of the Great North and South Fault which runs through by Parkhouse and Dalton, as shown in Plate XXXVIII., and it is curious to observe that all the deposits above noticed have a westerly "hade," that is to say, the faults along which they lie are down to the west. This is just the opposite of what is found in the Whitehaven District. There the North and South Faults are up to the west. But in that district the rocks have a westerly dip, whilst in this, where the vein-like deposits have been found, they dip south-east.

2.—*Dish-like Deposits.*—Most of the deposits in the district are of this kind. In their simplest form they are roughly-like filled irregular basins, just below the drift, but in some of the more complicated forms this resemblance is somewhat remote owing to the fantastic outline of their

sides. At other times deposits of this kind are so long as compared with their breadth that they seem almost like veins. Plate XLV. shows a plan and sections of two of the simpler forms of these deposits, at Tytup, one of which has been worked to the bottom, but the other is still working. Figs. 1 and 2, Plate XLVI., are plans of the Park deposit, the largest deposit of this or any other kind in the district. Fig. 1 shows the form of the deposit at 40 fathoms from the surface, and Fig. 2 its form at 50 fathoms. In an east and west direction the deposit measures about 360 yards, and in a north and south line its greatest length will be about 260 yards. The average thickness of the drift overlying the ore would be about 10 fathoms, and the deposit has been worked down from that level to about 83 fathoms from the surface, and the bottom of it is not yet reached. These figures it must be understood give an extreme idea of the size of this deposit. Besides, it contains large quantities of sand and clay, to be hereafter noticed, but still it is an enormous mass of ore, and there is no deposit of the same kind in Furness which approaches it in size. There are many deposits larger than those shown in Plate XLV., as for instance those at Mousell, Crossgates, and Lindal Cote, but they are nothing like Park in size.

Branches of ore from these deposits frequently assume a vein-like form which are called "ginnels." They are, however, different from the vein-like deposits just described. In the latter, one cheek is *regular*, but in the former both cheeks are very *irregular*. Moreover, they do not *appear* to be laid along faults, but their direction corresponds nearly with the north and south joints in the limestone. Some deposits consist almost entirely of these "ginnels," as at Bolton Heads. Where such is the case they usually extend up to the drift.

These dish-like deposits, so common in Furness, are rarely met with in the Whitehaven district. There, nearly all the deposits are covered by a rock roof over the greater part of their area, although at some point or other they are almost sure to extend up to the drift.

3.—*Irregular-Shaped Deposits.*—There is only one good instance of this kind of deposit in the district, and that is at Askam. A plan and section of a small part of this deposit are given in Plate XLVII. As there shown, the ore seems to be entirely surrounded by limestone; but in another part of the deposit it lay immediately below the surface in a dish-like hollow, somewhat similar to the deposit at Park. In the discussion which took place on the writer's paper on the "Hæmatite Deposits of West Cumberland," published in Vol. XXVIII., of the Transactions,

Mr. Greenwell introduced a section of the Askam Mines which shows how the ore, as just mentioned, at some parts of it came up to the drift. Mr. Greenwell's section, however, showed the ore to be bed-like, which it is not. Moreover, there is no unconformity in the limestone above and below the ore as shown in Mr. Greenwell's section. From the main body of the Askam deposit numerous "ginnels" protrude like fingers from the hand, and the direction of these "ginnels" always corresponds with that of one or other of the main joints in the surrounding limestone, mostly with the joints running nearly N. and S. The total area of the deposit, including the large masses of limestone that project into the ore from the sides, roof, and sole, would be about 16 acres. Its length in a N. and S. direction would be about 260 yards, and from E. to W. it would be about 300 yards. It was overlaid by about 16 fathoms of drift, and on the dip side of the deposit where it had a rock roof, as shown in Plate XLVII., the ore extended to a depth of about 40 fathoms. Generally the deposit, notwithstanding its irregular form, had the same dip as the limestone, and it extended to a less depth on the rise side where it came up to the drift than on the dip side where it had a rock roof. This is a common feature of deposits both in this district and at Whitehaven.

Inner Nature of Deposits.—Hitherto only the form and position of the deposits have been noticed. Their internal peculiarities next demand attention. These are numerous and curious, and present some marked contrasts with those of the Whitehaven district. It will be remembered that one of the commonest features of the Whitehaven deposits is the occurrence in them of beds of shale which are interstratified with the surrounding limestone. In Furness this feature is rarely met with, for the very good reason that, as already pointed out, there are few beds of shale in the limestone. Still they are met with occasionally in the ore. Fig. 1, Plate XLVIII., is a section of one of the "ginnels" in the Askam deposit, which shows a thin layer of shale interbedded with both the limestone and the ore. Another section in the same mine, showing shale interbedded with the ore, is given in Fig. 2 of the same plate. Whether or not these beds extended into the limestone it is impossible to say, owing to the way in which the deposit was worked, but they had the same dip as the limestone. Fig. 3 is a section in the same mine, and shows a thin layer of shale forming the roof of a bed-like piece of ore. Fig. 4 shows the same kind of thing as it was exhibited at the north end of the Lindal Moor vein. In the same deposit the section given in Fig. 5 was exposed. It shows, in the ore, a thin bed of shale, which abuts against the fault on

one side. On the other side the boundary of the ore has not yet been reached, so that it cannot be said whether or not this layer of shale is interbedded with the limestone; but, as will be seen from the drawing, it has the same dip as the limestone, both above and below it.

In most of the deposits the ore is interrupted by masses of stone which frequently have an elongated form, their longer axes having a direction corresponding very nearly with the north and south joints of the limestone. These stony masses are usually connected either at one end or both, or at the bottom, with the main body of limestone in which the ore lies; that is to say they project into the ore from the surrounding limestone. Some smaller pieces of stone, having the shape of rough irregular spheres, are frequently embedded entirely in the ore, as shown in Fig. 6, which is a representation of one of these limestone balls as seen in Stank Mine. Fig. 7 shows another form of included limestone, as seen in the Lindal Moor deposit.

In some of the dish-like deposits large masses of red and white sand are met with. In the Park deposit there is a very large quantity of it, so much in fact that it is worked and sent to Barrow for use at the blast furnaces. The horizontal form of these sandy masses at Park is shown in the two plans of that deposit given in Figs. 1 and 2, Plate XLVI. Vertically they are as irregular as in plan, but are more or less continuous from the under side of the drift down nearly to the 70 fathoms level. In the 60 fathoms level there are blocks of Red Sandstone which in the centre cannot be distinguished from the St. Bees Sandstone. On the outer side of these blocks the sandstone is less hard and arranged in concretionary layers, which are softer and softer outwards until they disappear altogether in a mass of loose sand.

Frequently in the dish-like deposits, and occasionally in those having a vein-like form, masses of red, yellow, and whitish clay are met with. Sometimes this clay is quite hard, and then it receives the name of "hunger." The clay masses usually, but not invariably, occur around the outside of the ore between it and the limestone; or, as in the case of the Park deposit, between the ore and the sand. They are not continuous but interrupted, as shown in Plates XLV. and XLVI. Sometimes two or three fathoms of clay may be found between the ore and the limestone. At other times the ore can be seen abutting against the stone. In the latter case the limestone has a rounded outline, and is often decomposed to a depth of nearly an inch; or, to use the miners' expression, it has then a crust on it. In the deposits containing hard compact ore, the stone and

ore at their junction are often blended into one another in such a way that they seem to be "grown together," as is often the case in the Whitehaven district. This appearance is sometimes met with in the deposits containing soft ore, but not very often, except in small pieces, as might be expected.

In many instances, particularly in the Mousell Mines, the limestone on the outside of the clay appears to be very much broken up, and between the disjointed masses of stone some of the clay just spoken of has penetrated. Sometimes in the clay surrounding the ore vegetable matter is found, particularly in the deposits at Crossgates. In one or two of the mines there pieces of flattened exogenous wood, 6 inches to 8 inches diameter, have been found embedded in the clay on the outside of the ore; in one case at a depth of 24 yards from the surface in a mine which is overlaid by only about 4 yards of drift. Occasionally these clays enclose small *angular* patches of white sand and also angular, sub-angular, and rounded fragments of hæmatite, as shown in Fig. 8, Plate XLVIII. There is also associated with the clay a substance called by the miners "black muck," an analysis of which is given below :—

Analysis of Black Muck.

* Water at 212° F.	1·11
„ combined	5·56
Peroxide of iron	37·88
Alumina	2·86
Manganese oxide	11·97
Carbonate of lime	2·34
Magnesia	·45
Sulphuric acid	—
Phosphoric „	1·13
Insoluble silicious matter	36·70
	100·00

The miners sometimes call the dark *vegetable* matter previously alluded to "black muck," but the two substances to which they give that name, it need scarcely be said, are entirely different, except in outward appearance.

The ore found in the Furness deposits may be divided into three classes :—

1.—*Hard compact blue-purple ore*, in which there are numerous loughs, lined with kidney-like concretions and spar, such as occur in the

* This would have been very much greater if the analysis had been made soon after the sample was taken out of the mine. Being kept for about six months in a very dry place before it was analysed, a considerable amount of water was lost.

Whitehaven deposits. This kind of ore is found in the northern end of the Lindal Moor deposit, in the Stank deposit, and in part of the Askam deposit. Its composition is as follows :—

	1.	2.	3.
Ferric oxide	78·61 ...	83·00 ...	94·23
Protoxide of manganese ...	·24 ...	— ...	·23
Silica	16·45 ...	15·50 ...	4·90
Alumina	1·87 ...	— ...	·63
Lime	·56 ...	trace ...	·05
Magnesia	·24 ...	— ...	trace
Phosphoric acid	·03 ...	— ...	trace
Sulphuric acid	·04 ...	— ...	·09
Water	2·02 ...	1·50 ...	·56
	100·06	100·00	100·69
Metallic iron	55·03 ...	58·10 ...	65·98
Specific gravity	4·34 ...	4·53 ...	4·83

Loss of moisture in drying at 212 degrees F. would probably average one to two per cent.

Although the outward appearance of this hard ore suggests the idea that it is very compact, yet on being submitted to the microscope it is found to contain a number of minute cavities, as shown in Plate XLIX., which is a representation of a piece of this ore magnified 48 diameters. These cavities are mostly filled with silica, and their proportion to the mass is about the same as that of the silica in the above analyses, so that the silicious quality of these ores in this district, and in West Cumberland, is, as indicated by chemical analysis, and still further demonstrated by microscopic analysis, due to a mechanical admixture of quartz. The larger cavities in the ore that are visible to the unaided eye, and which are locally called loughs—also contain a quantity of silica in the form of quartz spar, but this will not much affect the analyses as most of it is thrown aside in working the ore. The kidney ore, when seen under the microscope, contains very few cavities, and as might be expected from that fact, its chemical analysis shows very little silica. The more silicious the ore the greater is the number of minute quartz-filled cavities which it contains. Fig. 1, Plate L., shows the form and mode of occurrence of some of the small loughs, but many of the larger ones are two or three feet in diameter. A few of these cavities are lined with calcite and specular ore, but they mostly contain quartz. Many of the loughs are *filled* with spar, others only partially so. The proportion of both filled and open loughs to the volume of ore will probably be about one-sixth. As in the Whitehaven deposits the kidney

ore is invariably found forming the walls of loughs, and it is never found apart from what was once a lough, although it may be that loughs which originally existed are now filled with spar, as shown in the figure last referred to. This hard ore is sometimes very curiously mixed with stone, as shown in Fig. 2, Plate L.

2.—*Dull reddish purple ore* which occurs in moderately hard pieces mixed with softer concretionary ore of a bright red colour, in some of the interstices of which there is a quantity of very soft, red, greasy-looking ore called "smit," which seems to be the same kind of ore as that forming the concretions, but in a powdery condition and mixed with water. The concretionary ore, on being subjected to the action of the atmosphere, and turned over a few times rather roughly, falls into a powder, which, when moistened, has exactly the appearance of "smit," and leaves the same red greasy stain. Under the microscope it is seen to contain a number of minute particles of quartz, which, in the pre-powdery condition of the ore, occupied cavities therein, similar to those found in the hard blue-purple ore.

This ore is found at the southern end of the Lindal Moor deposit, in part of the Stank deposit, at Yarlside, Crossgates, and elsewhere. The softest of it is known as "puddling" ore. Its composition is as follows :—

	1.	2. Dried at 212° F.
Ferric oxide	77·24	86·50
Protoxide of manganese	·11	·21
Silica	·09	—
Alumina	·24	—
Lime	6·00	2·77
Magnesia	·41	1·46
Carbonic acid	4·19	2·96
Phosphoric acid	—	trace
Sulphuric acid	—	·11
*Insoluble residue	9·07	6·55
Water	2·82	—
	100·17	100·56
*Silica	7·27	6·18
Alumina	1·47	·30
Lime	·08	—
	8·82	6·48
Metallic iron	54·06	60·55
Specific gravity	4·04	4·47

The harder pieces of ore, as already mentioned, contain microscopic cavities, some of which are filled with quartz, but many of them are empty. In this ore the loughs are smaller but more numerous than in the hard compact ore first described. When they contain spar it is generally calcite, very little quartz occurring in them. The soft kidney-like concretions in this ore are frequently found following the contour of included pieces of stone, as shown in Figs. 6 and 7, Plate XLVIII., and sometimes as in Fig. 3, Plate L., it may be seen in "ginnels" having the same relation to the limestone cheeks.

In this ore, at Gilbrow (the south end of the Lindal Moor deposit), a number of fossils belonging to the Carboniferous Limestone have been found, some converted into hæmatite, others only partially so.

3.—*Soft dark ore.*—This is the most abundant ore in Furness, being that which is mainly found in the dish-like deposits. It consists of hard pieces of ore like those last described, some of which have the kidney-form of the size of a man's hand, and less, set in a moderately soft, dark red or brown, and sometimes nearly black matrix, which consists of "smit," clay, and manganese; the whole mass having a most confused appearance. It contains no loughs, except such as are occasionally found within the harder pieces of it, and these are necessarily very small. Its composition is as follows:—

	1.	2.	3.	4.
Ferric oxide	60·61	69·81	75·35	84·47
Manganese	2·22	1·12	1·49	·22
Silica	21·93	15·38	7·27	6·95
Alumina...	—	—	2·10	—
Lime	·39	·21	·21	·25
Magnesia	·56	·70	·64	·41
Sulphuric acid	—	—	—	—
Phosphoric acid ...	·03	·02	·03	·03
Loss on ignition ...	3·76	3·44	2·54	1·58
Moisture lost at 212° F.	11·44	10·10	10·00	6·90
	100·94	100·78	99·63	100·81
Metallic iron	42·43	48·81	52·75	59·13
Specific gravity ...	3·66	3·78	3·98	4·30

In the other two classes of ore the kidney-like concretions are invariably found immediately adjoining loughs, but in this they are embedded in the softer ore, and altogether apart from loughs.

The distinguishing feature of this ore, chemically, is its comparatively large percentage of manganese. The second ore described contains a

high percentage of lime and carbonic acid, due probably to the presence of limestone. The hard compact ore contains little manganese but a large quantity of silica.

Before leaving this part of the subject, it is necessary to notice the distribution of the deposits. A glance at Plate XXXVIII. will show that they are mainly concentrated around the high ground about Haume, their number and extent decreasing as the distance from Haume increases; the only exceptions being the deposits at Stainton, Stank, and Yarlside, which are adjacent to the two great lines of fracture traversing the district, as will be seen on reference to Plate XXXVIII.

The minerals associated with the ore are, barite, calcite, pyrite, quartz, and manganite.

PART III.—AGE OF THE DEPOSITS.

In a paper on the "Hæmatite Ores of North Lancashire and Cumberland," read before the British Association, at Leeds, in 1858, Professor Phillips is reported to have said "that the date to which it" (the ore) "could with most probability be referred was that of some part of the Permian deposits." Other opinions on this subject are given in the writer's paper on the "Hæmatite Deposits of West Cumberland." In the discussion which took place after the reading of that paper, Mr. A. L. Steavenson quoted some remarks, published in the "Revue Universelle," on the mines of Somorrostro, in Spain, which were to the effect that the deposits there worked were formed during the Cretaceous period. It was not clear whether Mr. Steavenson wished to convey the impression that the deposits of West Cumberland and of Furness also were of Cretaceous age, but if so he was certainly in error, as shown by the fact that fragments of hæmatite are found in the Lower Permian breccia at Whitehaven and at Rougham Point (see Plate XXXVII.) This breccia does not occur in Furness, but it is found near Humphrey Head, in Cartmel, which is only about five miles away, and, as already pointed out, the physical changes undergone by the district under consideration so nearly resemble those which have taken place in West Cumberland, and, in fact, throughout the whole of the low ground surrounding the Lake District, that if the hæmatite in one part of the area can be shown to be of a certain age, it is extremely probable that the same kind of ore in other parts of that area is of a corresponding age. In the Whitehaven district the evidence on this part of the subject is so complete, and has been so fully dealt with in the writer's paper on "The Hæmatite Deposits of West Cumberland," that it seems altogether unnecessary here to prolong the discussion. The whole of the evidence

goes to show that the hæmatite of West Cumberland is of *early Permian age*. In Furness there is no special evidence on the point beyond that which is furnished by the breccia of Humphrey Head, in Cartmel, which shows that the ore there, and therefore in Furness, is certainly older than the bulk of the Permians, so that the ore both at Whitehaven and at Furness may be taken to be of the same age, that is early Permian. Additional reasons for this conclusion will be adduced when the origin of the deposits is discussed.

PART IV.—ORIGIN OF THE DEPOSITS.

On this question the opinions of other writers were given when dealing with West Cumberland. The conclusions arrived at in the paper on the "Mines of Somorrostro," referred to by Mr. A. L. Steavenson, are altogether opposed to the facts, as the writer can now very confidently assert, for, since the discussion took place which led to the mention of that paper, he had had an opportunity of going very carefully over nearly the whole of the mines in the province of Viscaya as well as over part of those in the adjoining province of Santander. Those deposits are much younger than these—younger even than was stated by the writer in the "Revue Universelle"—but they both tell the very same story as to their origin.

The Whitehaven deposits show clearly that the ore in them was not, as is often supposed, thrown down in caverns. One of the strongest facts upon which that conclusion is based is the occurrence in the ore of thin layers of shale, which are also interbedded with the surrounding limestone. In the Furness deposits very few of these shale beds are found, because there are very few of them in the limestone. Still, they are met with occasionally, as shown in Fig. 1, Plate XLVIII., and they prove the same thing here as at Whitehaven. Other facts, pointing in the same direction, are the frequent "growing together" of the limestone and ore, the presence in the ore of fossils belonging to the Carboniferous limestone, and of spherical and irregular pieces of limestone with kidney ore arranged in concretionary layers around them, as shown in Figs. 6 and 7, Plate XLVIII. All these facts, as pointed out by the writer in discussing the origin of the West Cumberland deposits, tend to show that these immense masses of hæmatite were formed by a replacement of the limestone. Another fact not there mentioned, but which has a similar import, may also be noticed. The existence of loughs and microscopic cavities in the ore is altogether incompatible with the supposition of its being a sedimentary deposit. They might exist in an igneous formation, although it is very unlikely that they would then have their present irregular form, but that

such was not the mode in which this hæmatite originated is clearly shown by the presence in it of the shale beds above alluded to. Now, replacement pseudomorphs of hæmatite after calcite, have precisely the porous appearance presented by the hard ore of this district and Whitehaven, a fact which renders it still more probable that the deposits of both districts originated by a process of replacement.

The average composition of the hard blue-purple, or of the softer reddish purple ore yielded by any deposit may perhaps be expressed as follows:—

Peroxide of iron by weight 85 per cent. (equal to 59·5 per cent. of metallic iron).
Foreign matter do. 15 do.

The specific gravity of peroxide of iron is about 5, and the average specific gravity of the associated foreign matter may be taken at about 2·24, so that the relative volumes of the two sets of material existing in the ore may be taken as 170 is to 67, that is to say, in 237 cubic feet of *solid* ore 170 feet will be peroxide of iron, and 67 feet foreign matter. But it is found that about one-sixth of the bulk of a deposit of *hard* ore must be allowed for loughs, which are either filled or empty, in other words, only five-sixths of such a deposit can be taken as ore. It appears, therefore, that in any deposit of hard hæmatite measuring say 999 cubic feet the volume is made up as follows:—

	Cubic Feet.
Peroxide of iron	598
Foreign matter	235
Loughs	166
Total	999

Thus it is apparent that in a deposit of hard hæmatite little more than one-half the volume of the ore (including loughs) is occupied by peroxide of iron, the remainder consisting of loughs and foreign matter. This foreign matter was probably deposited after the ore, and so filled up the minute pores which once existed in it; just in the same way as it is seen that many of the large loughs have been subsequently filled whilst others are but partially so.

The replacement of limestone by hæmatite may be effected in several ways in the laboratory, but, most probably, in the case of the deposits under consideration, it resulted from the action of an aqueous solution of either perchloride of iron or of bicarbonate of iron.

The reaction which ensues when an aqueous solution of perchloride of iron is brought into contact with limestone as is follows:—

$$Fe_2\,Cl_6 + 3\,(Ca\,CO_3) = Fe_2\,O_3 + 3\,(Ca\,Cl_2 + CO_2).$$

Or in other words peroxide of iron is precipitated, calcic chloride is held in solution, and carbonic acid gas is given off. If the reaction takes place at an elevated temperature, the hydrated precipitate may be altered to anhydrous hæmatite. In "Dana's Descriptive Mineralogy," 5th edition, p. 168, it is stated that "E. Davies has shown that the ordinary precipitate of hydrate of iron, on being boiled in water, may have its water reduced to 3·52 per cent. (J. Ch. Soc., 2, 4, 69) and Rodman (l.c.) has by the same method reduced it to 2 per cent., showing that the water varies with the temperature of origin, and, as Davies observes, no great heat is needed to make thus anhydrous hæmatite." In "Watt's Dictionary of Chemistry" (new edition, 1875), vol. 3, p. 395, more precise information on this head is given in the following statement :—" Ferric hydrate gives off part of its water between 80 degrees and 100 degrees C., and the whole at a red heat; it is also completely dehydrated by heating it from 160 degrees to 200 degrees C., with a saturated solution of chloride of calcium or chloride of sodium." By the above reaction, as already mentioned, a solution of chloride of calcium is produced, which needs only to be heated and the precipitated peroxide of iron would be deprived of its water. The manner in which the solution was heated will be noticed hereafter, but it is probable that a much less temperature than that mentioned above, if continued for a great length of time, might have the same effect.

By the action of bicarbonate of iron on limestone there results:—

$$Fe\,C_2\,O_4 + Ca\,CO_3 = Fe\,CO_3 + Ca\,C_2\,O_4.$$

In other words, carbonate of iron is precipitated, and bicarbonate of lime is held in solution. The conversion of the carbonate into the peroxide of iron is effected as follows:—

$$2\,(Fe\,CO_3) = Fe_2\,O_3 + CO_2 + CO.$$

Two volumes of the carbonate of iron being required to produce one volume of hæmatite, there is a loss from the evolution of carbonic acid and carbonic oxide of nearly one-third of the weight.

These reactions and changes necessitate the following relation in the volumes of hæmatite and limestone. From a solution of perchloride of iron, 999 cubic feet of limestone would precipitate only 290 cubic feet of hæmatite of the ordinary density, but it would precipitate a larger volume if the density were reduced. From a solution of bicarbonate of iron, 999 cubic feet of limestone would precipitate 438 cubic feet of hæmatite. This quantity is so much nearer than the previous one to the relative volume of peroxide of iron actually found in the deposits that, from these considerations alone, it might seem more probable that the replacement had been effected by means of a solution of bicarbonate of

iron rather than by a solution of perchloride of iron; but there are other reasons which necessitate the rejection of that supposition, as will hereafter appear.

It has been clearly shown that both here and in West Cumberland, the hæmatite was deposited at a time which was marked by great volcanic activity, that is to say, simultaneously with the formation of all the pre-Permian, or early Permian faults which intersect the Carboniferous limestone. This connection of itself suggests that the source of the iron was volcanic; but there are other reasons which point much more directly to that conclusion. Pre-Permian faults, it is known, occur everywhere throughout the Carboniferous band which encircles the Lake District, yet it is only at three points in that band, viz., Whitehaven, Millom, and Furness, that hæmatite has been found in large quantities. An examination of Plate XXXVII. will show that at each of those points the Skiddaw slate, which is the lowest known rock of the district, has been brought up to the surface. It has occupied that position, too, since pre-Carboniferous times, for the Carboniferous Limestone reposes on it at Cleator, at Millom, and in Furness. Now, without assuming anything so extremely uncertain as that the earth's interior, during Permian times, was in a fluid condition, it seems perfectly legitimate to infer that the violent fractures and dislocations which then took place resulted from great internal pressure due to a locally elevated temperature. That being so, is it not exceedingly probable that these fractures and dislocations would be accompanied by certain volcanic emanations? and seeing that the earth's crust would be thinner at those points where the Skiddaw slate was on the surface, than at other points where it was covered by rocks of a later age, and seeing that at those same points the uplifting action has been greatest, and that therefore the fractures and dislocations must there have been greatest too, it follows that there also the volcanic emanations would be most abundant. The way in which the hæmatite deposits of Furness are clustered around the older rocks of Haume, as shown in Plate XXXVIII., points clearly to the source of the iron. It may be said, of course, that they simply indicate that there the limestone was more broken up during the upheaval than it was farther away, and that, therefore, it would be more readily acted upon by any solution of iron brought into contact with it, no matter whether that solution came from above or below. But that would not be so, as will be hereafter shown. Besides it seems altogether impossible that the iron solution can have come from above, notwithstanding, that the deposits, as a rule, decrease in size downwards. Where could it come from above? There were no overlying rocks then, containing iron, as most of the Upper Carboniferous

rocks had been removed by denudation, and if the iron solution had come along the surface from a distance surely it would have found its way, as liquids do now, along valleys and other similar depressions in the ground, and would consequently attack the limestone along those valleys, so that there should be some intimate connection between valleys and hæmatite deposits; but no such connection is found. On the contrary, some deposits occur on ridges separating valleys, others on hillsides, and bearing in mind that the physical features of a district may have been greatly altered since the Permian era, yet it is difficult to conceive how or by what means the face of any district can have been so altered that a valley exists now where there was formerly a hill, and *vice versa*. Again, if overlying rocks had been the source of the iron, it might be expected ore would be more frequently found in the uppermost bed of limestone, as it would first intercept the descending solution. It might also be expected that deposits found in the neighbourhood of Urswick would be quite as large as those found nearer Haume. That the fractures in the rocks near Haume were larger than at Urswick matters little, for the merest joint at either place would soon be widened by the action of the iron solution, and the precipitated material would, for a long time, be so loose and porous that it would offer very little resistance to the percolating waters, so that a difference of a few inches in the width of the primary joint would not affect the ultimate size of a deposit. That is rather a question of circulation, for it is quite clear that the more rapidly a mineral solution passes through the rocks the greater, in any given time, will be the precipitate resulting from the chemical action of that solution on the rocks through which it passes. Now, there might be a better circulation at Urswick than near Haume; at any rate, it is impossible to say that it was not quite as good, nor is it possible to show that the conditions promoting circulation were better at the one place than at the other.

If the salt of iron which effected the replacement be supposed to have come from below in a gaseous condition, and to have been dissolved, before reaching the surface, in the waters circulating through the rocks in the neighbourhood of Haume, where, as already pointed out it was most reasonable to look for volcanic emanations, then the whole of the facts presented by the distribution of the hæmatite deposits of Furness become as simple and as easily understood as any other geological proposition, and the very same remarks will apply to the deposits of Millom and of Whitehaven, by localising the volcanic action respectively at Black Comb, and near Dent. It is known that perchloride of iron dissolves in water with considerable evolution of heat, so that there would be the high temperature

which it has been shown is necessary for the dehydration of the precipitated peroxide of iron. Then again, circulation being, as a rule, greater along lines of fracture than through the body of the rock; the occurrence of deposits by the side of faults is easily understood; and since the iron solution would attack the limestone as soon as it was brought into contact with it, and as it would be most readily brought into such contact along lines of fracture near its source, the reason for the localisation of the Furness deposits around the high ground at Haume, and along the two main fractures traversing the district, is at once apparent. By the time the solution, in its course through the rocks, reached Urswick and the more eastern parts of the district, it would be robbed of most of its iron. At Millom and Cleator the limestone band is so narrow that it is impossible to say whether or not there is a corresponding diminution in the size of the deposits, as the distance from the source of the iron increases. But in viewing the deposits in this connection, there naturally arises one most important question. Why is it, seeing that the Carboniferous limestone is resting on the Skiddaw slate all the way from Egremont to Cockermouth, that hæmatite occurs most abundantly between Egremont and Rourah? The explanation of that fact is probably as follows:—The boundary between the Skiddaw slate and the large area of volcanic rocks on the south is known to be a faulted boundary. There is thus adjacent to the Whitehaven hæmatite area, as will be seen on referring to Plate XXXVII., an important fracture in these older rocks. Then, again, from Egremont to Rourah the Carboniferous limestone is very much faulted, whilst between Rourah and Cockermouth there are very few faults. These facts seem to indicate that the uplifting action which produced the faults was greater near Egremont than in the direction of Cockermouth, and therefore in addition to the rocks being more seriously dislocated at the former than at the latter place, thereby facilitating to a greater extent the action of the aqueous solution on the rocks, there would be a greater number of passages formed for the escape of the iron from below. So that whether attention is turned to the distribution of the deposits in the Whitehaven district or of those in Furness, the suggestion is irresistibly made that the source of the iron was volcanic.

The gradual diminution downwards in the size of the deposits is explained by the fact that the circulation of underground water is greatest near the surface, and that it gradually diminishes downwards until a plane is arrived at, where there would be no circulation at all but for differences of underground temperature. This downward diminution of circulation must necessarily produce a downward decrease in the precipitate resulting

from the chemical action of any mineral waters passing through the rocks. Thus the wedge-like form of mineral veins is not, as is often supposed, a proof that they are filled fissures, but is a natural consequence of the differences in circulation of underground waters.

The *source* of the iron being volcanic, it is clear that the replacement was not effected by a solution of carbonate of iron, as that salt is easily decomposed by heat, and is, therefore, not found among volcanic emanations; but the perchloride of iron is one of the commonest of volcanic products. According to the preceding calculations, however, it appears that a deposit of hæmatite produced by the action of perchloride of iron on limestone, would only contain about half as much peroxide of iron as is actually found in the deposits of this district and of West Cumberland. But it must be borne in mind that perchloride of iron has the power of holding, in solution, a considerable quantity of peroxide of iron* which, when the critical stage is reached in the reaction, is deposited along with the proportion of iron locked up in the perchloride, so that the deficiency indicated by the calculations may have been supplied in that way; or it may have been precipitated by lime or other salts in the water. In "Watt's Dictionary of Chemistry," 1875, Vol. III., page 379, there occurs the following interesting statement on the solubility of peroxide of iron in perchloride of iron:—

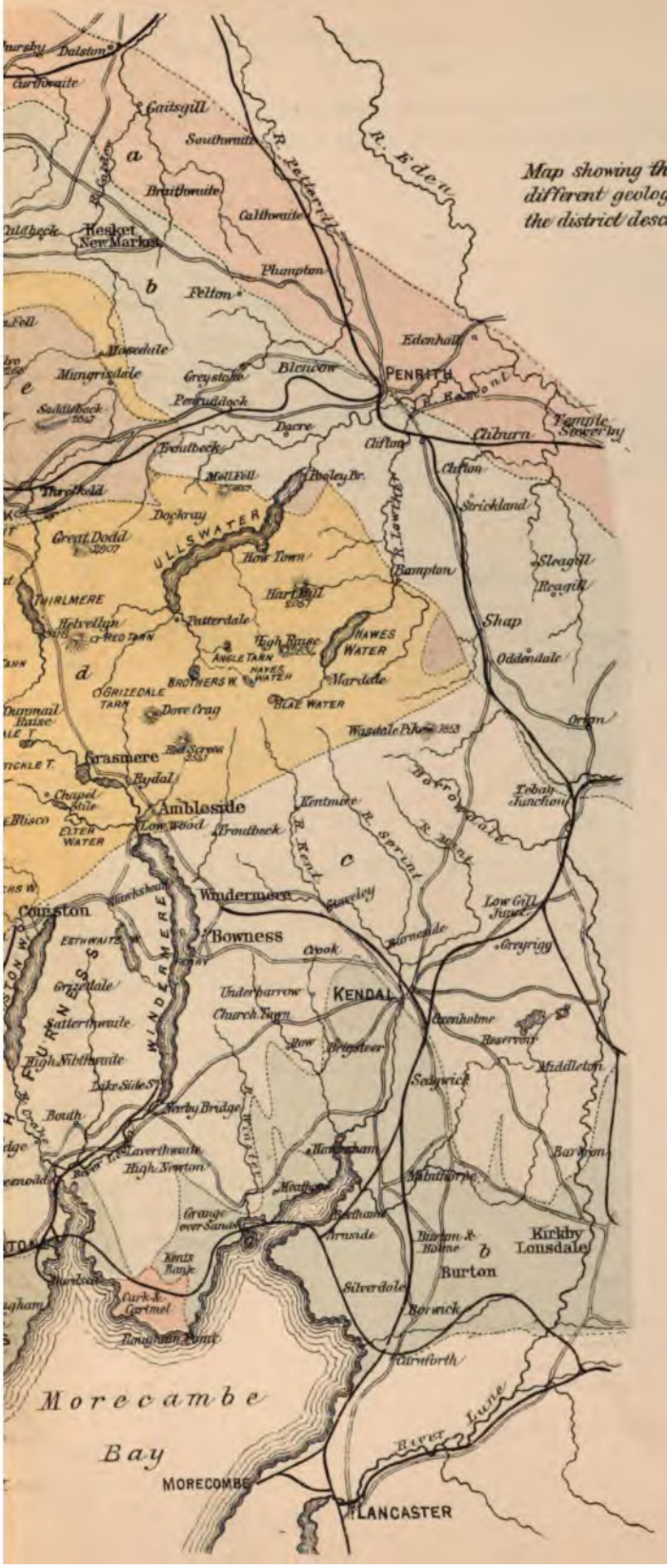
"Soluble ferric oxychlorides, or basic chlorides, are obtained by adding recently precipitated ferric hydrate to aqueous ferric chloride. The hydrate dissolves in considerable quantity, and a deep red solution is formed containing from five to six or seven molecules of ferric oxide to one molecule of the chloride. The solutions may be heated or diluted with water without decomposing; those which contain the larger quantities of oxide deposit a portion of it, however, on the addition of certain salts, and when evaporated leave residues which do not re-dissolve in water. Compounds containing not more than 10 at $Fe_2 O_3$ to 1 at $Fe_2 Cl_6$ are, on the contrary, perfectly soluble in water after evaporation. (Phillips' Phil. Mag., [3] viii. 406; Ordway Sill. Am., [2] xxvi. 197; Béchamp Ann. Ch. Phys., [3] lvi. 306, lvii. 296.)"

The sand and clay, so common in the Furness deposits, have clearly been deposited in loughs and caverns in the limestone subsequently to the formation of the ore. The porous nature of the ore and its proximity to the surface, in such deposits as contain clay, would favour the admission of carbonated waters to the limestone surrounding it. Thus caverns would be formed on the outside of the ore, which would need only to be filled with argillaceous and arenaceous materials to present the appearance of the pockets of sand and clay, which are found along the outside of the

* The writer was unaware of the solubility of peroxide of iron in perchloride of iron, until he was informed of it by Mr. A. Kitchin, F.C.S., of Whitehaven.

To illustrate Mr. J. D. Kendall's paper

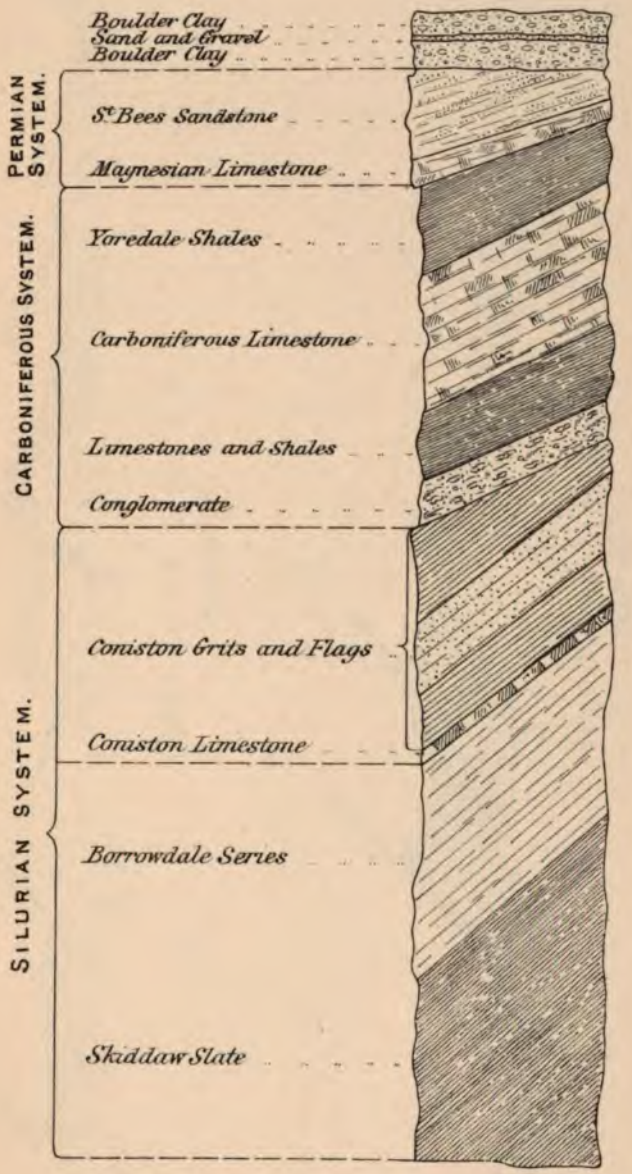
Proceedings No. E.I. of Ma. M.E. 1881-82



Map showing the relations of the different geological formations in the district described

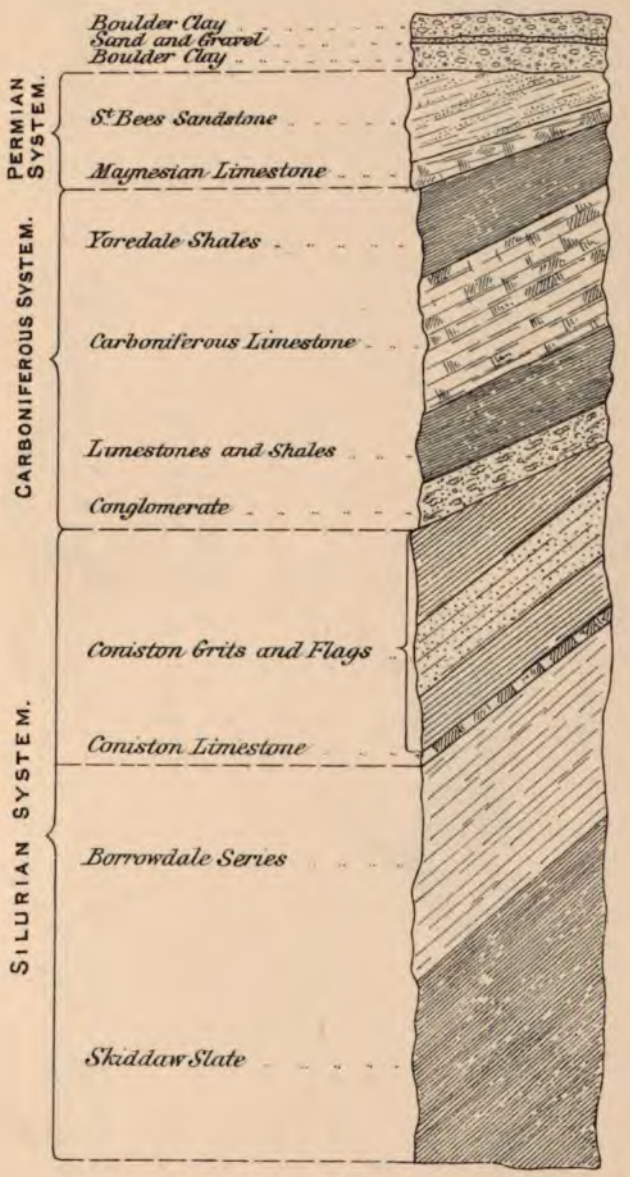
To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

SECTION SHOWING THE COMPARATIVE DEPTH AND THE SUCCESSION OF THE ROCKS DESCRIBED.



To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

SECTION SHOWING THE COMPARATIVE DEPTH AND THE SUCCESSION OF THE ROCKS DESCRIBED.



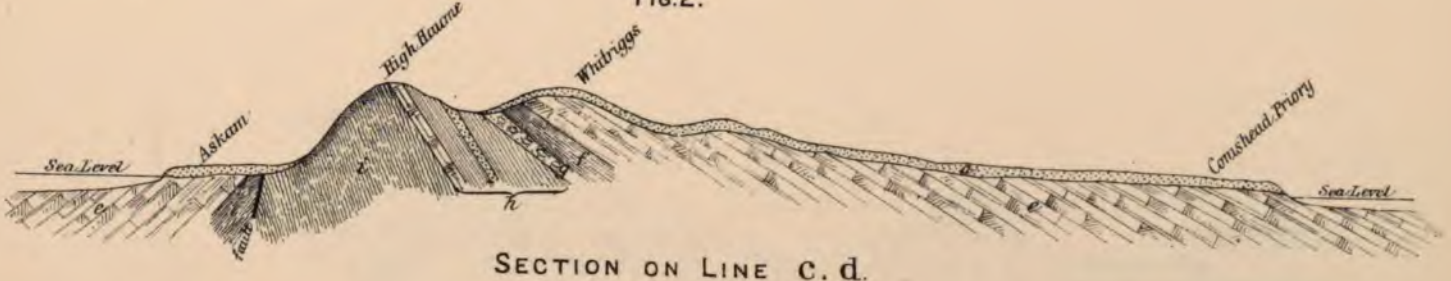
To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

FIG. I.

SECTION ON LINE a. b.

(PLATE XXXVIII.)

FIG. 2.



SECTION ON LINE c. d.

(PLATE XXXVIII.)

Scales.
Horizontal _ 1 Inch to a Mile.
Vertical — 800 Feet to an Inch.

REFERENCE.

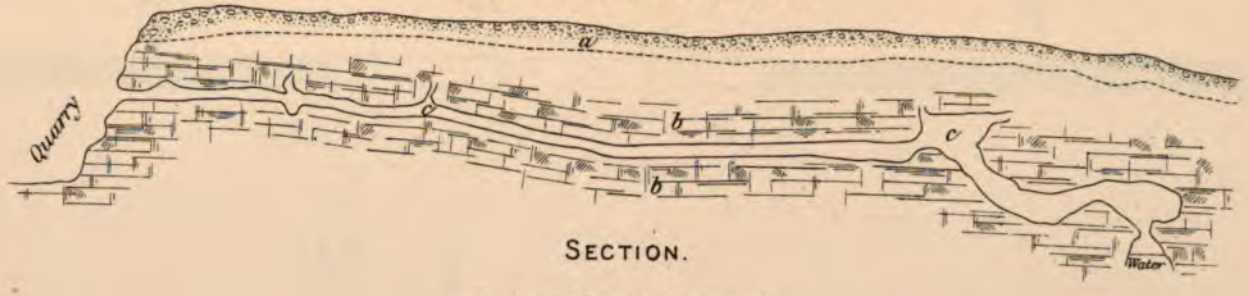
a. Boulder Clay, &c.
b. St. Bees Sandstone.
c. Magnesian Limestone.
d. Yoredale Rock.
e. Carboniferous Limestone.
f. Limestones and Shales.
g. Conglomerate.
h. Coniston Series.
i. Skiddaw Slate

Proceedings No. E.I of Nth. M.E. 1881-82

Ind. Roy. Sp. Soc.

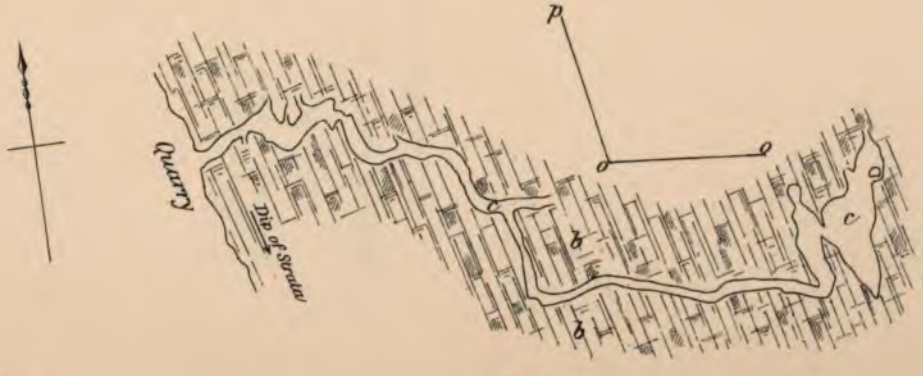
To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

CAVERN AT STAINTON.



SECTION.

Scale 120 Feet to an Inch.



PLAN.

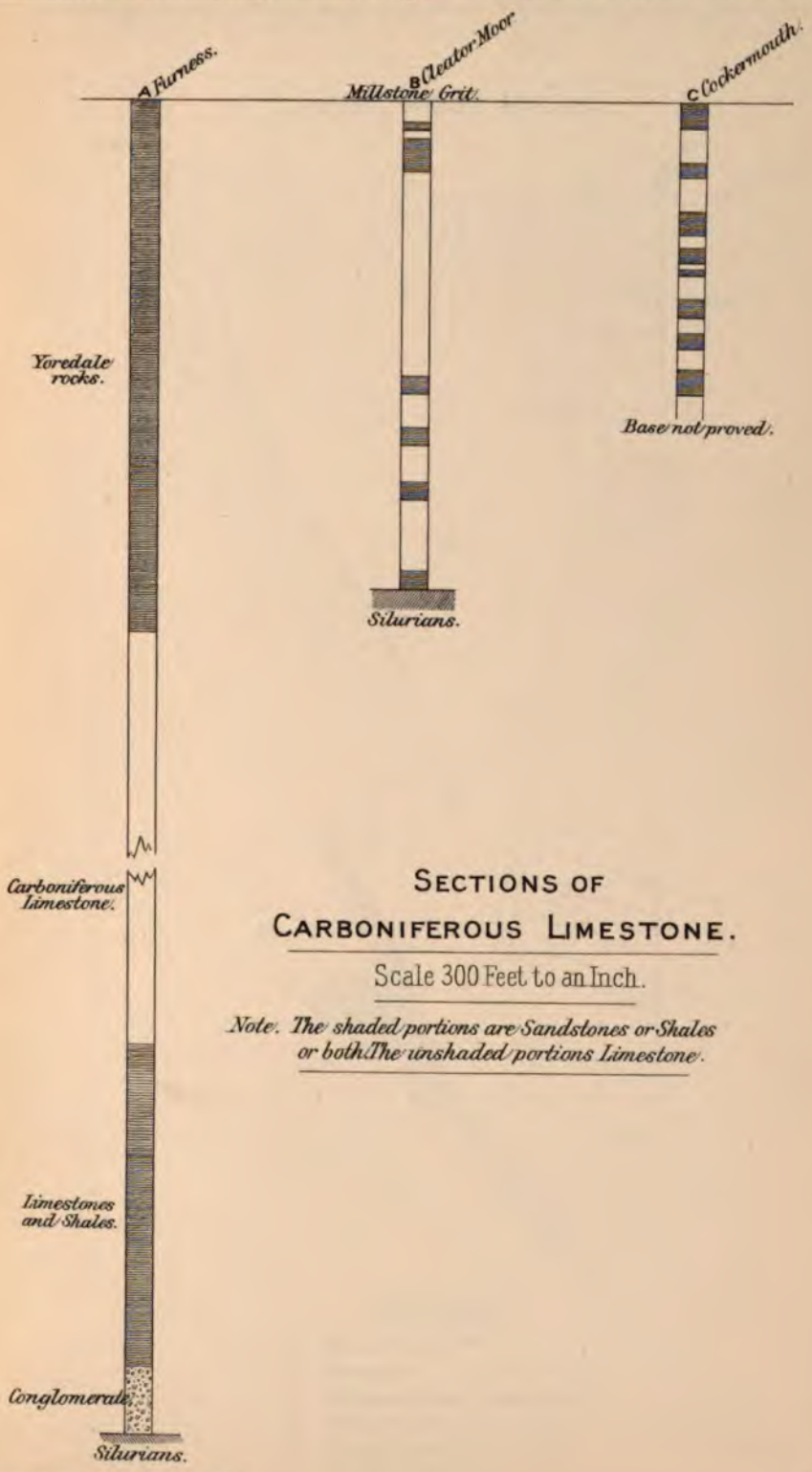
REFERENCE.

a Boulder Clay.
b Carboniferous Limestone.
c Cavern.
OP & OQ direction of main joints in Limestone.

Proceedings No. E.I. of M. & M.E. 1881-82

Ant. Reid, Newcastle

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."



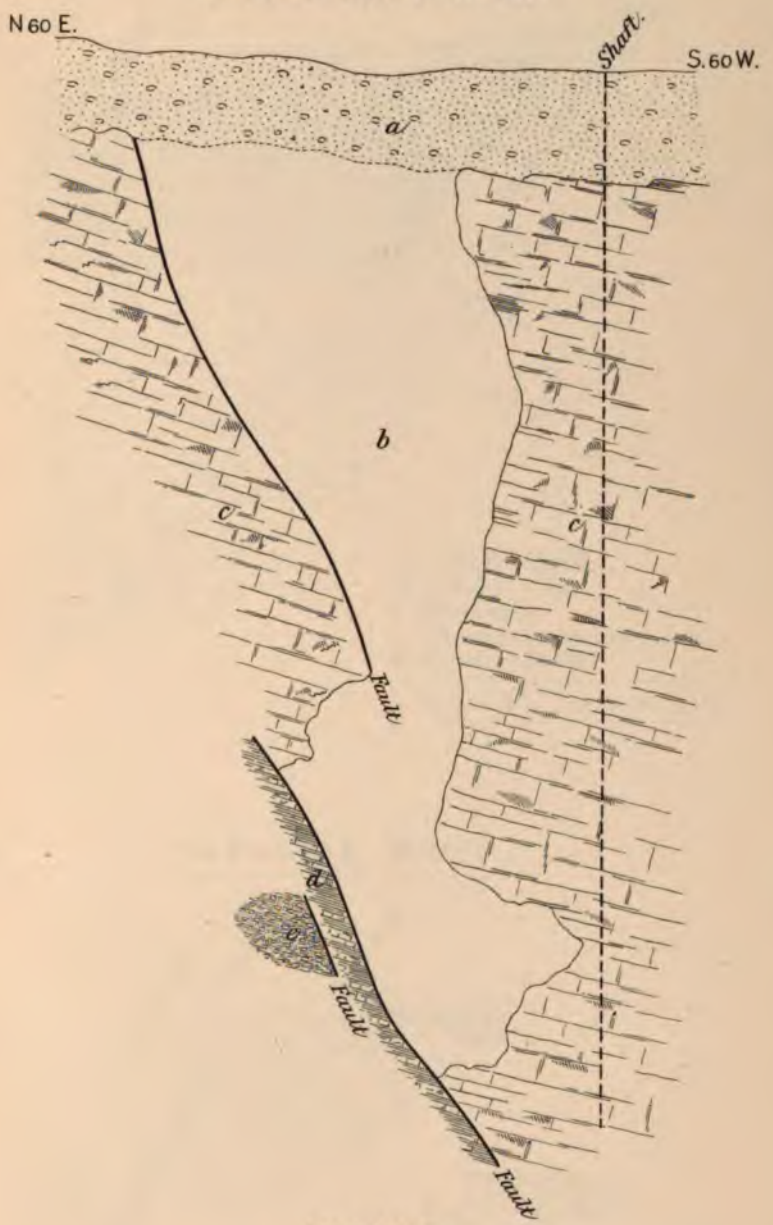
Sections of Carboniferous Limestone.

Scale 300 Feet to an Inch.

Note. The shaded portions are Sandstones or Shales or both. The unshaded portions Limestone.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness"

LINDAL MOOR MINES.



REFERENCE.

a Boulder Clay.
b Hæmatite.
c Carboniferous Limestone.
d Limestones and Shales.
e Conglomerate.

Scale 60 Feet to an Inch.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

STANK MINES.

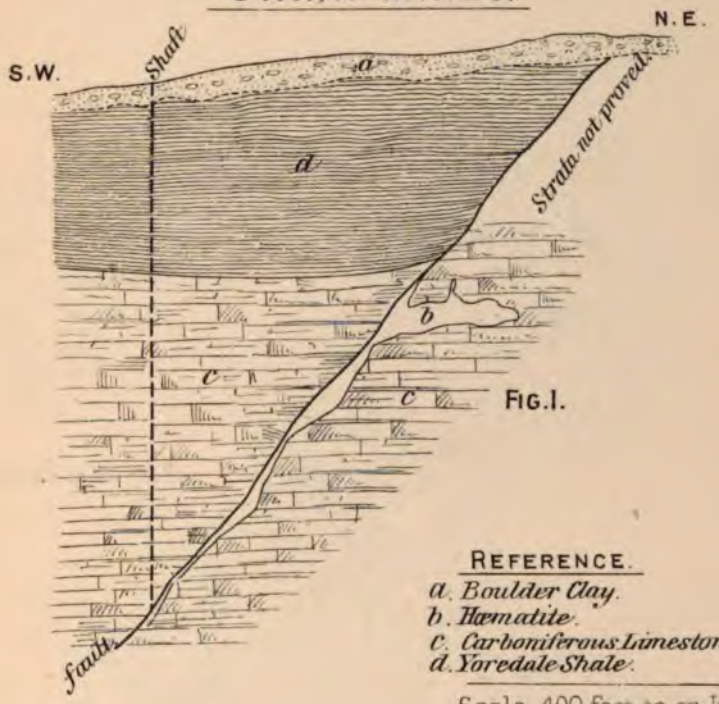


FIG. I.

REFERENCE.

a. Boulder Clay.
b. Hæmatite.
c. Carboniferous Limestone.
d. Yoredale Shale.

Scale 400 feet to an Inch.

YARLSIDE MINES.

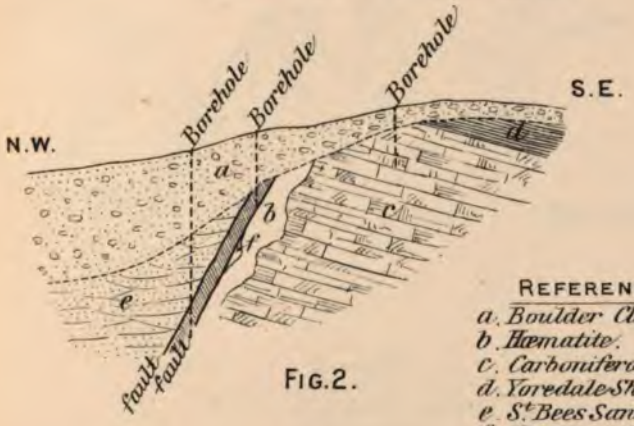


FIG. 2.

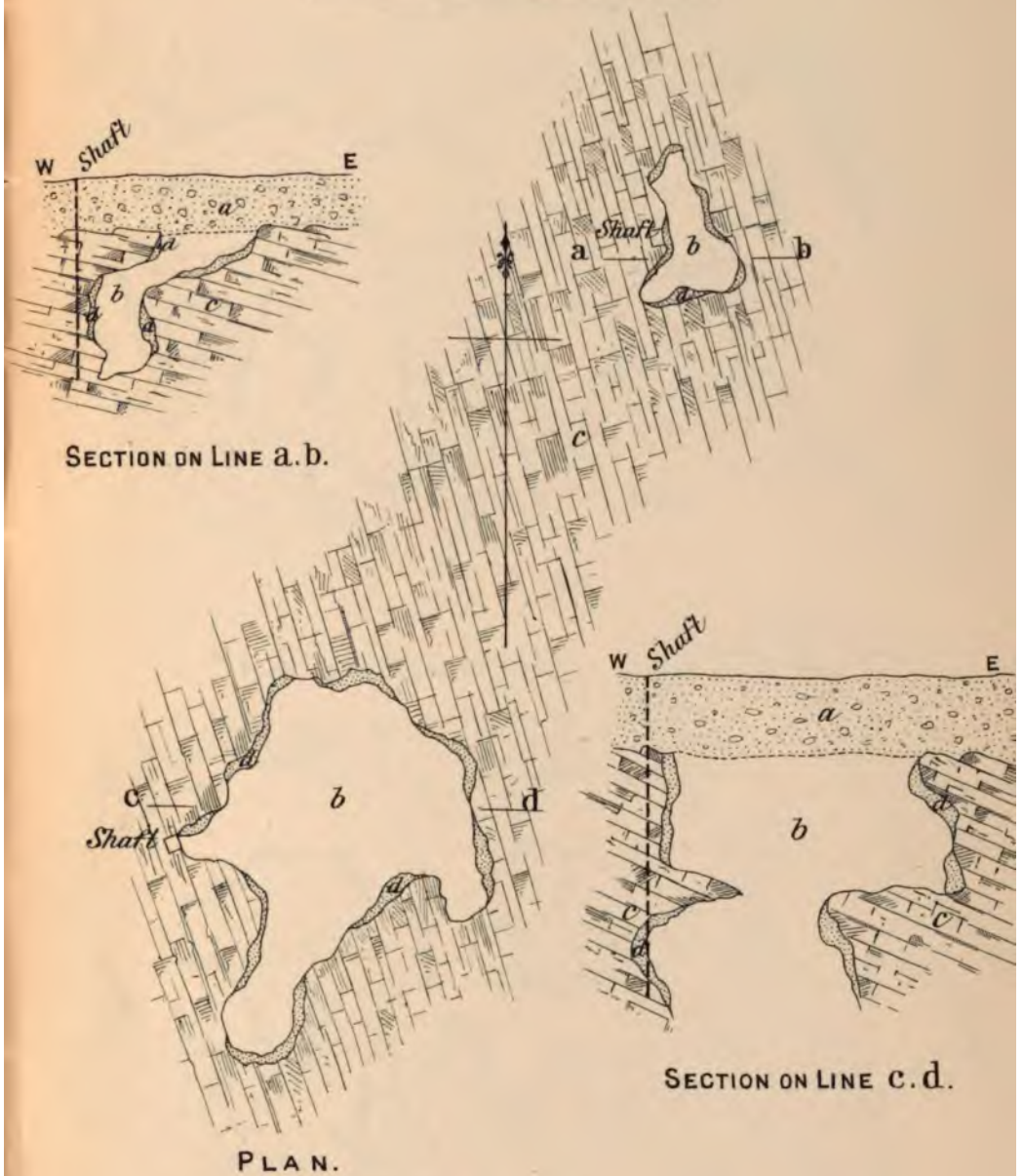
REFERENCE.

a. Boulder Clay.
b. Hæmatite.
c. Carboniferous Limestone.
d. Yoredale Shale.
e. St. Bees Sandstone.
f. Siliceous Stone.

Scale 400 feet to an Inch.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

TYTUP MINES.



REFERENCE.

a. Boulder Clay.
b. Hæmatite.
c. Carboniferous Limestone.
d. Clay, &c.

Scale .60 feet to an Inch.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

PARK MINES.

PLAN AT 40 FATHOMS LEVEL.

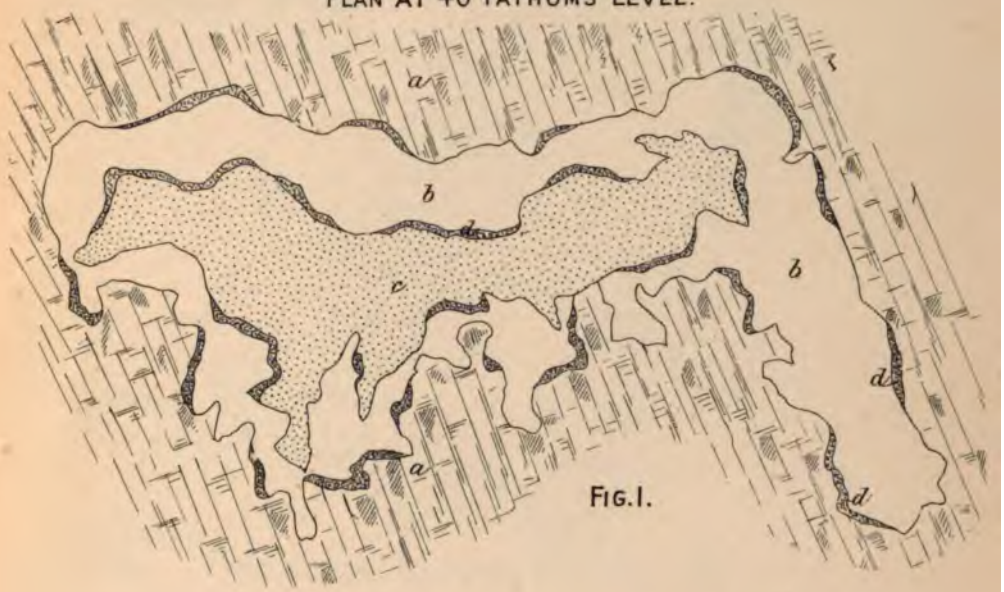


FIG. 1.

PLAN AT 50 FATHOMS LEVEL.

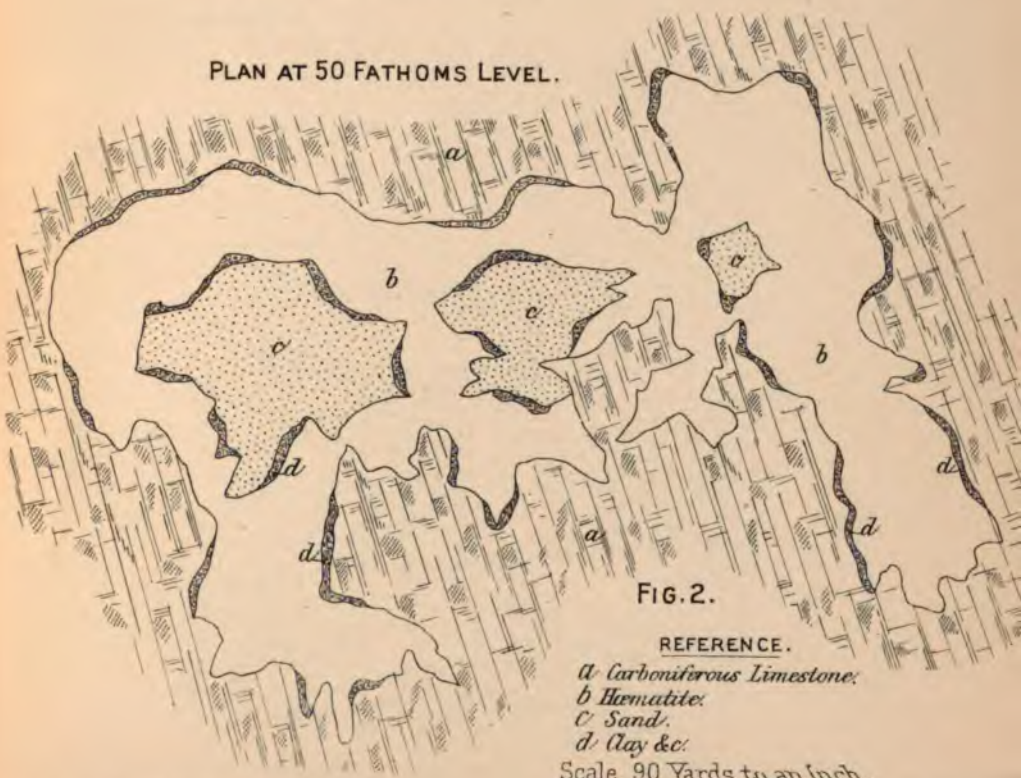


FIG. 2.

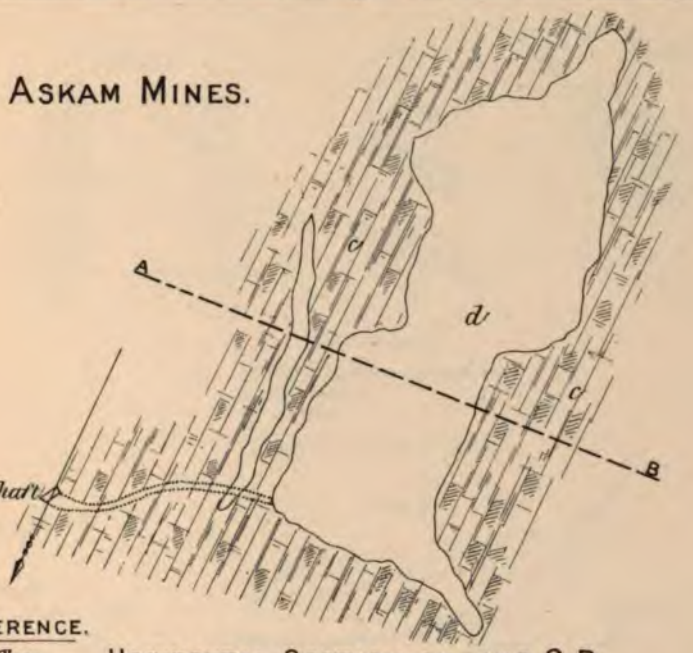
REFERENCE.

a Carboniferous Limestone.
b Hæmatite.
c Sand.
d Clay &c.

Scale. 90 Yards to an inch.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

Askam Mines.



REFERENCE.

a Boulder Clay.
b Sand.
c Carboniferous Limestone.
d Hæmatite.

Horizontal Section on line C.D.

Vertical Section on line A.B.

Scale. 60 Feet to an Inch.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

FIG. 1.

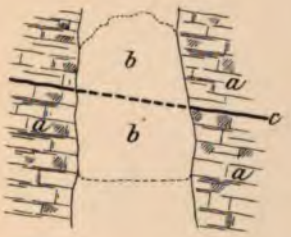


FIG. 2.

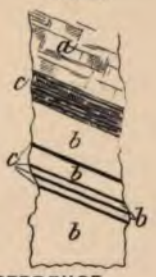
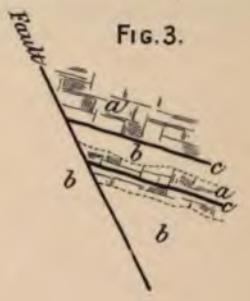


FIG. 3.

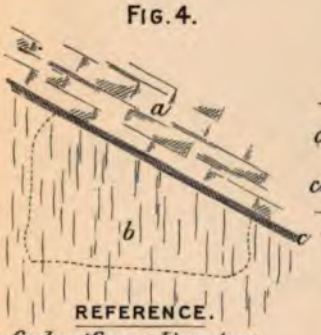


REFERENCE.

a Carboniferous Limestone
b Hæmatite
c Shale

Scale 8 Feet to an Inch.

FIG. 4.



REFERENCE.

a Carboniferous Limestone
b Hæmatite
c Shale

Scale 8 Feet to an Inch

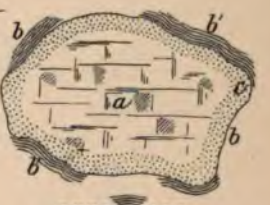
FIG. 5.

REFERENCE.

a Carboniferous Limestone
b Hæmatite
c Shale

Scale 16 Feet to an Inch

FIG. 6.

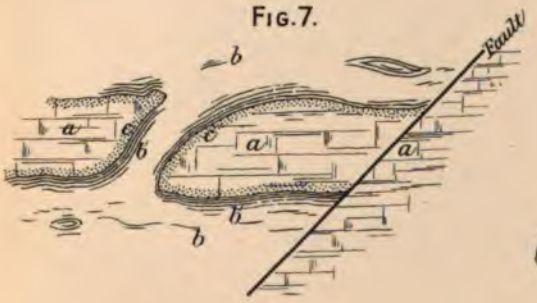


REFERENCE.

a Carboniferous Limestone
b' Hæmatite Kidney
b Hæmatite Massive
c Do. " poor

Scale 2 Feet to an Inch

FIG. 7.

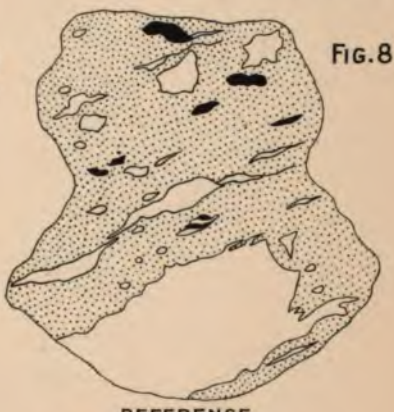


REFERENCE.

a Carboniferous Limestone
b' Hæmatite Kidney
b Hæmatite Massive
c Do poor

Scale 8 Feet to an Inch.

FIG. 8.



REFERENCE.

• Pieces of Hæmatite
D Sand white yellow and brown
S Black muck and clay

Scale Full Size

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

Magnified. 48 Diameters.

REFERENCE.

a. Hæmatite.

b. Quartz.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

Magnified. 48 Diameters.

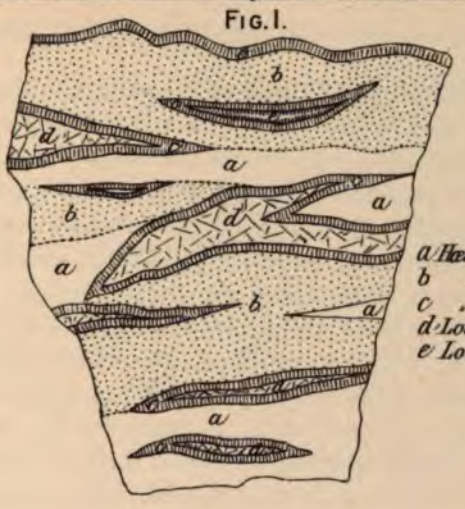
REFERENCE.

a. Hæmatite.

b. Quartz.

To illustrate Mr. J. D. Kendall's paper on "The Hæmatite Deposits of Furness."

Fig. 1.



REFERENCE.

a Hæmatite good massive.
b . . siliceous.
c . . kidney like.
d Loughs full of Quartz.
e Lough lined with Specular Ore.

Scale ½ Full Size.

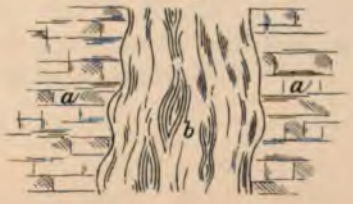
Fig. 2.

REFERENCE.

a Hæmatite good.
b . . siliceous.
c Limestone. . .
d Lough.

Scale ¼ Full Size.

Fig. 3.



REFERENCE.

a Carboniferous Limestone.
b Hæmatite.

ore in the dish-like deposits. It is not a little interesting to contrast the heterogeneous character of the materials contained in these cavernous deposits with the complete absence from the ore of any foreign matter whatever, except such as may have been introduced chemically.

The broken nature of the ore found in nearly all the shallow deposits, is the result of some forcible action that has taken place since the ore was consolidated. This is shown by the occurrence in the deposits of broken pieces of hard ore having a kidney-like form where there is now no lough nor any indication of one but the kidney ore itself. This result might have been brought about by the intense frost which prevailed during the glacial period. Water collecting in the loughs and pores of the ore becoming frozen would, if there were cavernous spaces or caverns filled with soft material round the outside, in all probability break the ore to pieces, as then the resistance to outward pressure would be little, if any, more than the tensile strength of the ore.

The clay which is found in the interstices of the broken ore has probably been carried down by water recently, from the overlying glacial deposits.

The PRESIDENT said, that this important and carefully prepared paper, to which they had listened with great interest, treated of geological questions which must, of course, require consideration, and which would probably raise some discussion. The paper would be open for further consideration in connection with Mr. Kendall's paper on "The Iron Ores of Antrim."

Mr. JOHN DAGLISH said, that, unfortunately, he was called out of the room during the reading of the paper, but he had heard enough of it to make him appreciate the valuable addition it would be to their Transactions, and if the proposed excursion was made to the district described by Mr. Kendall, the paper would prove a valuable guide-book to the members. He proposed a vote of thanks to Mr. Kendall for the paper.

Mr. A. L. STEAVENSON said, he had great pleasure in supporting the motion. He had entirely forgotten that on a former occasion he had taken part in the discussion referred to by Mr. Kendall. The opinions which he then gave were not his own opinions, and he did not want it to be understood that he thought the hæmatite deposits were of the cretaceous period. The remarks attached to his name were those of the writer in the "Revue Universelle."

Mr. J. A. RAMSAY said, there was a deposit of hæmatite a few miles south of Carlisle, and it certainly was not of igneous formation. It was lying in beds. Several borings had been made showing different thicknesses of this ore varying from some feet down to a few inches; he had himself seen specimens of the borings.

The PRESIDENT—Perhaps Mr. Ramsay will prepare a paper on the subject.

Mr. J. A. RAMSAY said, he would have pleasure in doing so if such information as he had would be sufficient for a paper. However, from the place he had referred to, to higher ground near Kirkby Stephen, deposits of hæmatite could be traced. He had made several tours through the district, and on one occasion he had the pleasure of Mr. Kendall's company.

Mr. JOHN MARLEY seconded the vote of thanks which was unanimously agreed to.

Mr. T. J. Bowlker's "Description of a New Ventilating Fan" was discussed:—

The PRESIDENT said that Mr. Bowlker had come from a distance at considerable inconvenience to discuss his paper, and as many other gentlemen were present who were desirous of taking part in the discussion, it would be more convenient to proceed with it now, and take Mr. E. P. Rathbone's paper on the "Dry, or Wind, Method of Cleaning Coal," as read.

Mr. WIGHAM RICHARDSON said, he was very glad that this paper had been brought forward; and he hoped some gentlemen present, who had had some experience in fans, would favour them with their opinions upon the invention in question. He had had no experience in connection with the large fans used for ventilating mines; but he had tried a large number of fans in connection with foundry cupolas and smiths' fires, and the results had been extremely puzzling to him. He had tried Roots' blower and Schiele's fan, and also the ordinary old-fashioned fan, which was simply like a paddle working in a case. He had tried Lloyd's fan, but had never been able to come to a conclusion as to why in some cases one fan seemed to be better than another. As he understood Mr. Bowlker's idea, it was to reduce the friction of the air on the sides of the casing by reducing the size of the fan. He thought that every day they were finding more and more that the question of friction was of the greatest importance in respect to questions in connection with

which until now it had been to a great extent perfectly ignored. It was a trite axiom that friction and heat were correlatives; but they sometimes forgot that, if friction produced heat, it was another way of saying that it lost power. The experiments which for many years past had been carried on by Mr. Froude on the resistance of vessels going through water had almost revolutionized the ideas of naval architects upon the amount and distribution of power required in propelling ships through water. Mr. Froude went so far as to consider that, up to a certain point, say 9 knots, the whole resistance of the ship was simply and entirely friction. The late Mr. Ericsson, of the United States Navy, or, at any rate, of New York, was so much impressed with the importance of this, that he proposed to lubricate the hulls of ships in going through the water by pumping air at the fore-foot and along the keel, so as to form a glove of comparatively frictionless air between the water and the ship. Last year he met Mr. Thorneycroft, who has built torpedo boats and yachts which have attained a marvellous speed, and he (Mr. Thorneycroft) told him there was no doubt that experiments would have to be made in the same direction as Mr. Ericsson had pointed out, and that he himself was preparing to build a yacht to go at a high speed, and to put such powerful appliances on board that he would be able to maintain a glove of air between the water and the ship. He thought that Mr. Bowlker, in dealing with the air so as to reduce the friction was in the right direction, and as he understood that the fan had been successfully in work for some time, it looked like a success. There were gentlemen present, however, who had had large experience with different kinds of fans, and if there was a weak point in the invention which did not strike himself—he only spoke of it abstractedly as an engineer—he hoped it would be pointed out.

Mr. D. P. Morison said he thought the last speaker had fallen into a slight error when he attributed friction to the air from the fan case itself. Experiments had been made by placing several water-gauges upon the case of a Guibal fan (of which he understood this fan was supposed to be, he would not say an improvement, but a modification) showing a depression of air or partial vacuum in the casing, and proving without any doubt whatever that no friction occurred attributable to the fan casing. Consequently, the idea of three outlets was not, he thought, in any shape or way supported by the assumption of any friction of the air within the case. M. Guibal made experiments some years ago with two outlets, but after the result of those experiments, he confined himself to a single outlet with a properly adjusted shutter. He thought, however, that a great improvement could be made by means that might be devised to

overcome the vibration which was found in all fans, both small and large. This vibration was dispelled by taking exactly the opposite course proposed by Mr. Bowlker; for instead of facilitating the escape of air by numerous openings, the vibration (which was really loss of power) was minimised by restricting as much as possible the area of the outlet, and the width of the tips of the blades. If the discussion was adjourned he hoped to be able to lay before the Institute the formulæ and drawings explanatory of this assertion.

Mr. W. Cochrane said, he had prepared some notes, but had not brought them with him, as he had understood that the discussion of this subject was to be deferred in order to be considered along with some kindred paper. One main point in the paper that he had noted was the unfair comparison made between a machine 8 feet 6 inches diameter, driven by a band, and a large one of 45 feet diameter. The small fan would give a higher useful effect, being worked up to its full power, than a large fan not worked up to the full effect it was capable of exerting; therefore, without any regard to the system, this alone might account for the advantages, if any, claimed for the smaller fan. The system was decidedly a retrograde one, in his opinion. It was an approach to the open circumference which he thought had been shown to be a thorough mistake. By the arrangement they had no facility whatever to alter the fan to suit the varying condition of the mine; whereas in the Guibal the sliding shutter was capable of adjustment. Again, how could they construct a fan of this kind when sizes above 8 feet or 10 feet were required? The enormously extravagant price for construction in masonry or iron would be an objection to the fan on a large scale. If the discussion was adjourned he would look up his notes upon the subject.

Mr. A. L. Steavenson said he agreed in the main with Mr. Morison and Mr. Cochrane. If three outlets were better than one, six or more would be better still, and ultimately they would get on to the open fan. He had seen the fan at work. It seemed to do very well, and for the work done was very small, but it worked noisily, and noise was loss of power. The Guibal was, he thought, the best theoretically; but they had to consider the first cost, and then the maintenance of the machine. Many Guibal ventilators had broken down on account of their great size; and a large one of 45 feet diameter could not be worked at a speed sufficient to develop its full theoretical effect for any time without breaking down, so that practically large Guibal fans worked constantly at a great disadvantage when compared with smaller ones, and, of course,

if a smaller one could do the work, it would be an advantage even were the absolute effect not so favourable. He had a Guibal broken down a few weeks ago, and since that the Castle Eden Guibal fan had broken down. Mr. Cochrane objected to the increased cost of the Bowlker fan, but he could not follow him in this, for if they could get a fan of 12 feet which would give as much air as a 40 feet fan, it was natural to conclude that the first cost and maintenance of the small fan would be less than that of the large fan; and if Mr. Bowlker could get up to 45 or 50 per cent. useful effect, as in the Schiele fan, which had never been known to break down, he thought the invention would be a useful one, even if by a slight percentage the Guibal gave the best result, and under all the circumstances he rather inclined to the smaller fan. He was at present considering what was to be done about two fans, and the whole matter would have his best attention, and when Mr. Morison brought his views forward he would join him in the discussion.

Mr. HENRY LAWRENCE said, that there were more Guibal fans at work than any other class, and the percentage of breakage was very small.

Mr. W. COCHRANE said a point had been raised by Mr. Steavenson as to large and small fans. He (Mr. Cochrane) merely wished to say that the Guibal, of any diameter, would give a better result than any other fan; and he hoped Mr. Steavenson would not think it a necessity of Guibal's fan that it should be of a large diameter, such as 30 or 40 feet. He did not see why Mr. Steavenson should say a Schiele should run better than a Guibal.

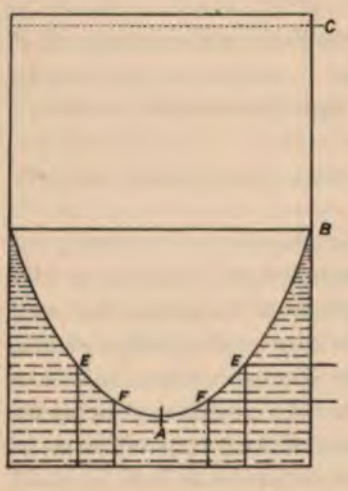
Mr. STEAVENSON—Because it is made of one piece and is of a stronger form.

Mr. W. COCHRANE doubted that. Guibal's ventilator was capable of being made as strong as any other, and a constructor ought to be ashamed of himself if he could not put up a Guibal which would work to the full extent without breaking down.

Mr. A. L. STEAVENSON—But they do break down, probably owing to the great vibration.

Mr. T. J. BOWLKER said, he would certainly like a little more proof before he could believe that, as Mr. Morison had said, there was no friction inside of the Guibal fan. Mining engineers at the present time were generally more or less conversant with the laws which governed natural phenomena, and were aware of the fact that where air was in motion there was always a certain amount of friction; and if a candidate, going up for his certificate of competency, were asked to find the friction of the air in a Guibal when its periphery was moving at sixty miles an hour, he would

not say it was zero, but very far from it. At all events, if he did say it was zero, he would certainly not obtain his certificate. He would like Mr. Morison to explain why air, as soon as it got inside a Guibal fan, suddenly ceased to obey the ordinary laws of nature. Although the water-gauge showed a decreased pressure at the interior of the walls of the Guibal fan, that only meant that the air there was at a comparatively infinitesimally diminished pressure, and did not prevent the air rubbing against the sides all the time. Mr. Morison had referred to experiments made on a Guibal fan with two outlets, which proved that they gave no better result than one, but he considered that he had obtained a better water-gauge by his fan, and that his three outlets answered their purpose quite as well as the single one of the Guibal fan. The water-gauge got by a fan might be found by multiplying the square of the velocity of the tips of the vanes in feet per second by certain multipliers. He took the three instances of the Guibal fan given in the report of the Committee appointed by the Institute to experiment on the various fans working in different parts of the country. The multiplier for the Hilda fan was ·00029, for the Cannock Chase fan ·00024, and for another fan ·00025. The multiplier for his fan was ·00029, which was as high as that for the 50 feet Guibal fan. Theoretically it ought not to give such a high water-gauge as the Guibal, and this he thought could be made plain to the members by the aid of a diagram. In a paper read by Mr. Cochrane a year or two ago the water-gauge of the Guibal was shown in this way. If a quantity of water were made to rotate in a cylindrical vessel its surface would be of the form shown in the woodcut, and would



cause a difference of pressure between the centre and the circumference equal to the height from *a* to *b*; and if the water were allowed to escape by an *evasée* outlet, there would be an extra difference of pressure equal to that from *b* to *c*; but if the water were allowed to flow in through an opening of diameter *f f*, the height due to that portion, since it did not rotate, would be lost. Now in the Guibal fan the opening was about one-third of the whole diameter, whereas in the fan in question the opening was one-half of the whole diameter. Thus the Guibal ought theoretically to get

a water-gauge equal to *f c*, whilst his fan ought to get one equal to *e c*, whereas it practically got one equal to the Guibal. Mr. Cochrane had stated that a smaller fan, if worked to its full extent, gave a higher useful effect than a large fan not worked to its full extent. He did not see how that was, so long as the periphery speed and water-gauge were the same. He thought the contrary was enforced in the remarks on the subject in the President's Address last year. With regard to the moving shutter in the Guibal, he thought at first it might be necessary to put some arrangement equivalent to a shutter on his fan, but when a fan was put up without one, and experiments tried, he found a shutter would be quite superfluous, unless the conditions were very varying indeed, and then it would be better, in most instances, not to put down a fan until it was found what the condition of the mine was. Suppose a fan was put up of capacity to get 200,000 feet of air per minute, and that it was found that with a certain water-gauge only 100,000 feet were going round; and suppose the maximum useful effect of the fan was 55 or 56 per cent., then with the smaller quantity of air the useful effect would be much less, and he did not think a shutter would affect it much. For instance, at Hilda, the fan, he thought, was shown in the report to give only about 40 per cent. of useful effect; and if there had been a much larger quantity of air through it, it would have given a better useful effect. With regard to the size of the fan, a fan of his type 18 feet 6 inches diameter, with a water-gauge of 4 inches, would be able to circulate 200,000 cubic feet of air through a mine, and that was as much as was required in almost any of their largest mines.

The PRESIDENT said, the discussion would be adjourned, and if Mr. Bowlker would favour them with his presence at the next meeting, it would be continued then.

Mr. D. P. MORISON said, if the discussion were adjourned to the next meeting, he thought he would in the meantime be able to get his figures, etc., ready.

The following paper by Mr. E. P. Rathbone, on the "Dry, or Wind, Method of Cleaning Coal," was taken as read.

THE DRY, OR WIND, METHOD OF CLEANING COAL.

By E. P. RATHBONE.

This method of cleaning coal is based on the separation of the shale or other impurities from the coal by means of jets or currents of air blown upon the coal at a constant and previously determined pressure. In order to accomplish this satisfactorily, the coal, etc., must first be subjected to a careful classification by means of a trommel or revolving screen, the result being that all the pieces reserved for separate treatment will be about one size, but will vary in weight according to their specific gravities. To make this quite plain the writer has drawn an imaginary diagram, Plate LI., representing a jet of air blowing upon a mass of material made up of pieces of coal, shale, and iron pyrites, all of one size, with the exception of the fine particles of dust adhering to the pieces.

From this diagram it will be observed that the distance to which the particles are projected is in direct relation to their specific gravity, viz., the coal being the lightest is blown furthest, the shale next, and the iron pyrites falling closest to the muzzle of the blast.

A system of cleaning coal, theoretically based on this principle, has been successfully introduced, and is to be seen in practical operation at the "Rhein-Preussen" Colliery, in Westphalia, being the invention of the managing director, Mr. Hochstrate.

Although the machinery employed is of a most interesting character, still, it appears to the writer that the system is open to many improvements and modifications, especially in the event of its being applied in any way to coal-cleaning in this country.

The advantages claimed by the inventor, especially that of having perfectly dried coal to deal with in the coke ovens, are of an importance which can hardly be exaggerated. It is therefore hoped that this paper, if it serves no other purpose, may be the means of directing attention to this subject.

The following description of this system was published in the "Revue Universelle des Mines" for January and February, 1881 :—

At the "Rhein-Preussen" Colliery the coal, as it comes from the shaft, is tipped directly on to a screen of the "Briart" type (viz., movable bars worked by eccentrics), marked *a a* Plate LII. The bars of this screen are set about two inches apart. The screened coal, viz., that which passes through the bars, passes into a box beneath and is conveyed by the Archimedean screw *b* into the large revolving screen or classificator *c*, by means of which the coal is separated into the following sizes:—Quarter-inch, quarter-inch to half-inch, half-inch to three-quarter inch, and three-quarter-inch to one inch.

The fifth size, or that which passes out at the end of the screen, is composed of pieces of a size varying from one to two inches, which are not treated in the cleaning apparatus but pass directly on to an endless strap or band *d*, from which the pieces of shale, etc., are picked by hand, the coal thus cleaned passing directly into the railway wagons.

For each of the other four sizes a separate cleaning apparatus is required, as will be seen from Plates LIII. and LIV. The revolving screen *c* is partly enclosed by iron sheeting *s*, which serves to guide the screened coal on to the movable screen *f*, Plate LIV.

This screen (which receives a slight end-percussion motion) serves to spread the coal evenly in the chamber or channel *g*, in which the actual cleaning of the coal takes place.

Before proceeding further, it would be well to give a description of the construction of this channel *g*.

It is divided into two compartments by an iron grating. At one end of this channel the mouth of the fan *h* is fixed; the other end opens out into the dust chamber *i*. Inside this compartment and below the grating, there is an endless band *k* revolving in a direction contrary to that of the air current.

The cleaning of the coal is accomplished as follows:—

The coal passing from the screen *f* falls upon the grating in the channel *g*, and, being subjected to the force of an air current, slides forward into the hopper *l*. The very fine particles of coal dust are blown by the air current into the dust chamber *i*, the pieces of shale, etc., falling on to the iron grating, and passing through it on to the endless band below. Particles of coal are prevented from passing through the grating along with the shale by allowing the current of air to enter into the space above the endless band and below the grating.

The pieces of shale, etc. (dirt), only pass through the grating when their weight is sufficient to overcome the pressure of the air beneath. When that is the case they fall through the bars on to the endless band

k, which conveys them on to the general endless band *n*. The coal dust which is carried into the dust chambers is also partly deposited in two other chambers i^1 and i^2, which are divided by partitions, as shown in the plate.

In order to avoid the least possible loss a jet of steam is introduced into the chamber i^2, the opening of which is closed by a straw covering.

The produce from the first chamber *i* is removed by the screw *p* to one end, from which it is raised by the bucket elevator *r* into a large hopper, from which it is run out into the small coke wagons in the usual manner.

CONDITIONS FOR SATISFACTORY WORKING.

1.—The strength of the air current should be directly proportionate to the size of the coal treated.

2.—The grating in the air chamber should be so inclined towards the mouth as to allow the coal to glide easily forward, at the same time allowing the shale and dirt to pass through it. The sizes of the holes in the movable screen and in the grating must be directly proportionate to the size of the screened coal.

The results of working on this system will be found in an abstract of a paper by Messrs. Basiaux and Léonard, page 11 of Abstracts of Foreign Papers, showing that 50·5 per cent. of the whole output was cleansed by the wind separation, the percentage of dirt amounting to 6·1 per cent.

ADVANTAGES OF THE DRY OVER THE WET METHODS OF CLEANING COAL.

1.—The cost of the former is estimated at only a fraction of that of the latter on the same quantity of coal treated (*i.e.* with some of the foreign systems, as Lührig's).

2.—The manipulations being few, the coal and dirt are not so likely to get broken up into smaller pieces (an important point in dealing with tender or brittle coals). The fine dust which adheres to the different particles of coal, etc., is completely removed, and does not result, as in the wet way, in the production of a fine coal mud too dirty to be of any use for the manufacture of coke.

3.—By avoiding the accumulation of mud, the loss consequent on small particles of coal being invariably disseminated throughout the semi-liquid mass in the treatment by any wet process is also avoided.

4.—The dry way does not necessitate the making of large reservoirs for the reception of the coal mud.

5.—The dry coal gives the very best results in the manufacture of coke.

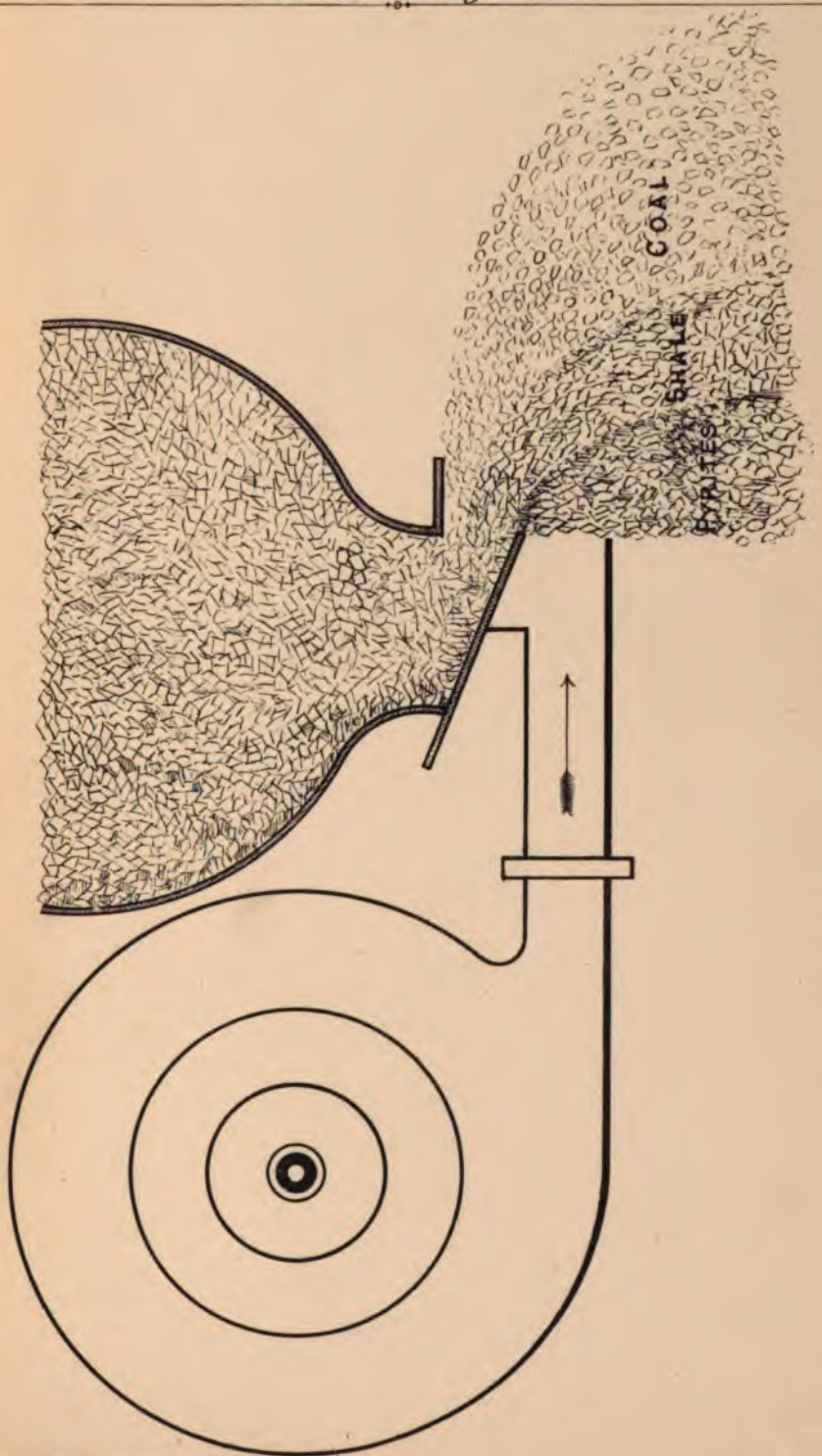
6.—The wear and tear in the coke ovens and in the coal-washing machinery is not nearly so great in dealing with dry material.

7.—The time occupied in making the coke when the substance is dry is of necessity much shorter.

The cost for the erection of a complete establishment to treat from 500 to 600 tons per day is also set forth in the abstract already referred to.

The cost of cleaning the coal is about 6d. per ton, and the quantity treated 600 tons per diem.

To illustrate Mr. E. P. Rathbone's paper on "The dry, or wind, method of cleaning Coal."



To illustrate Mr. E. P. Rathbone's pape

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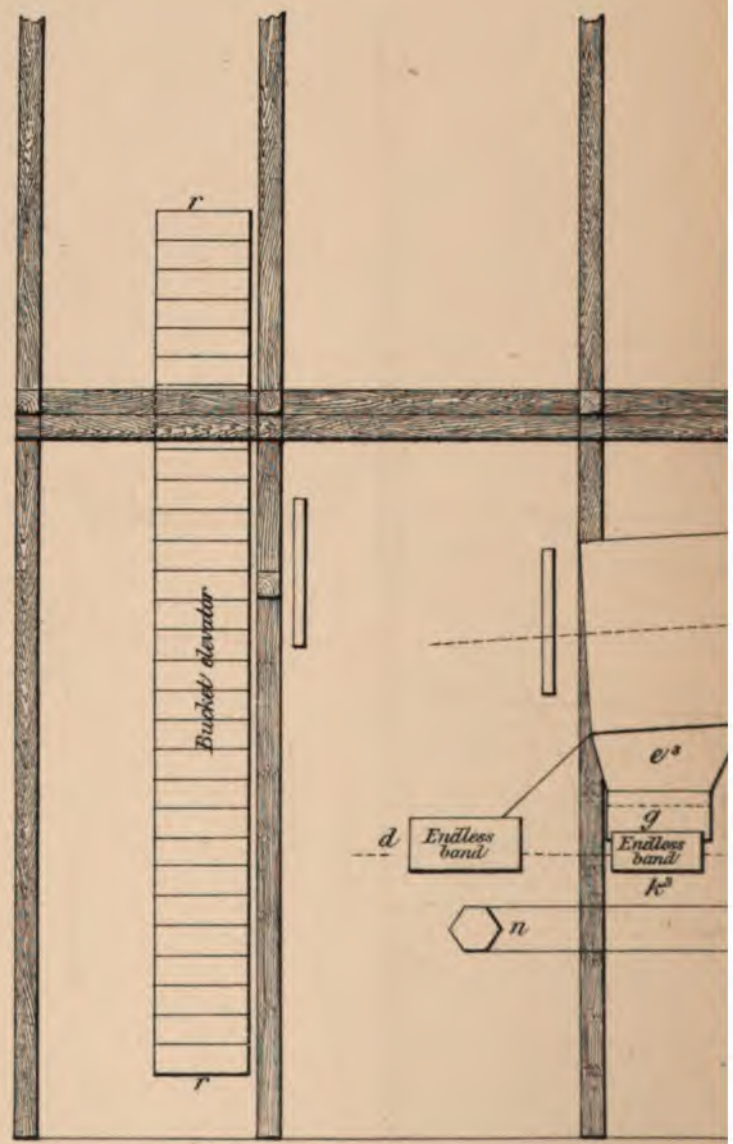
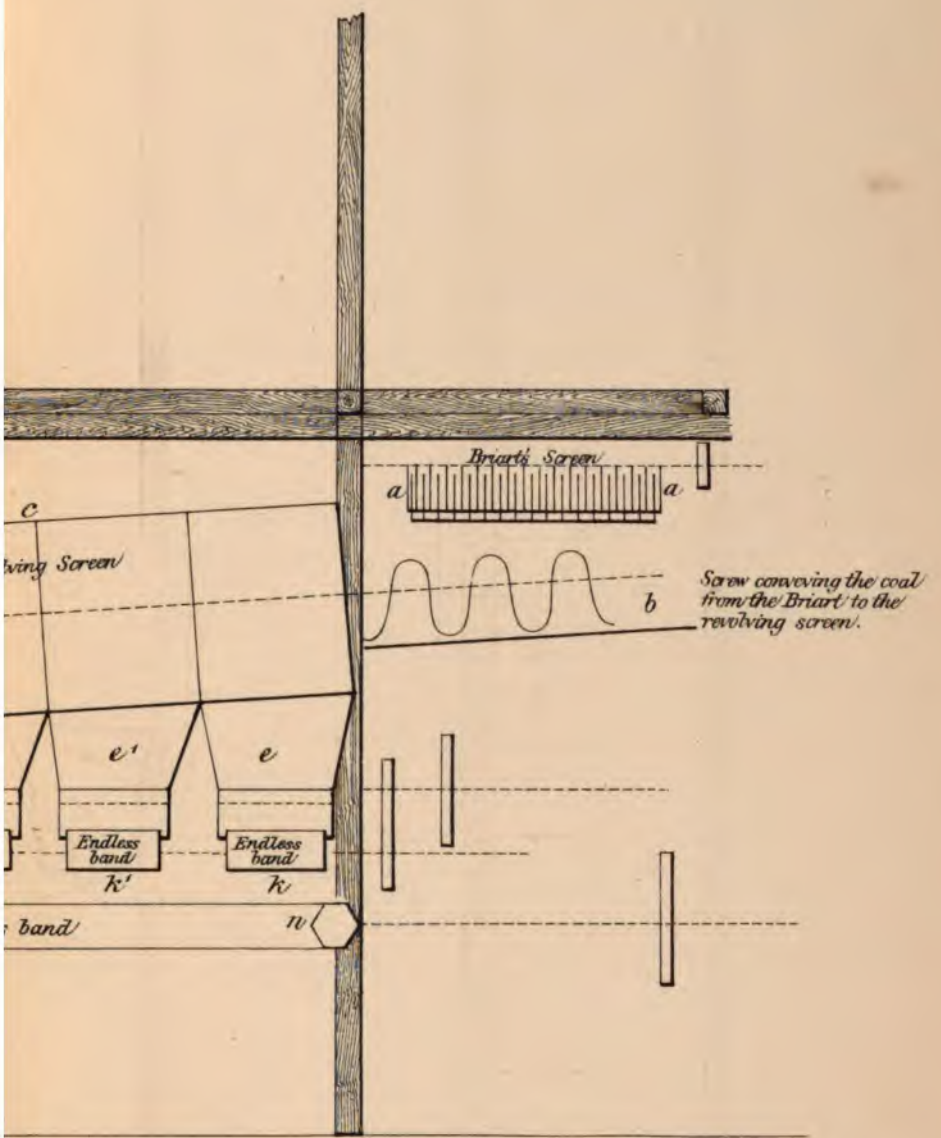
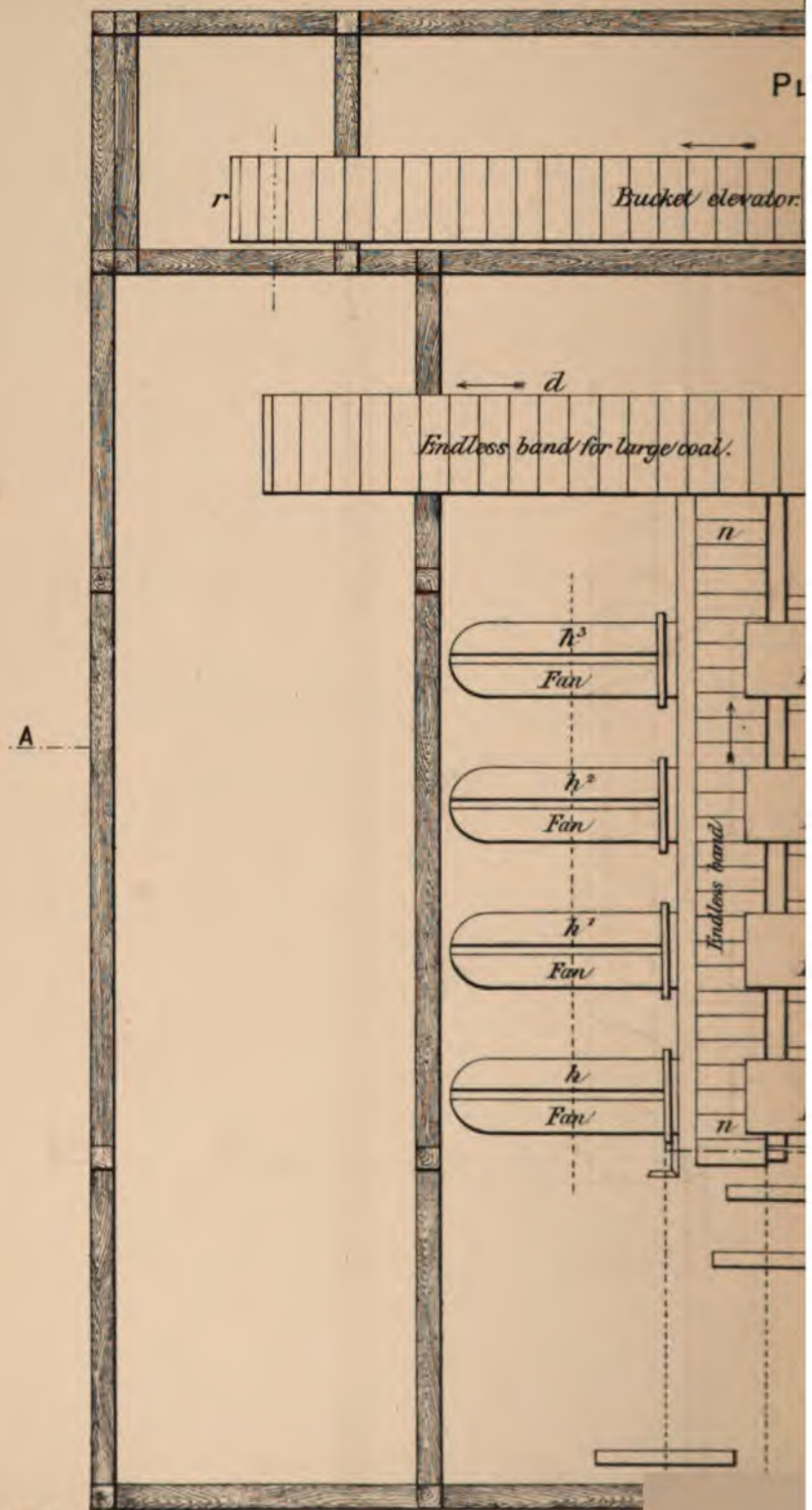


dry, or wind, method of cleaning Coal."

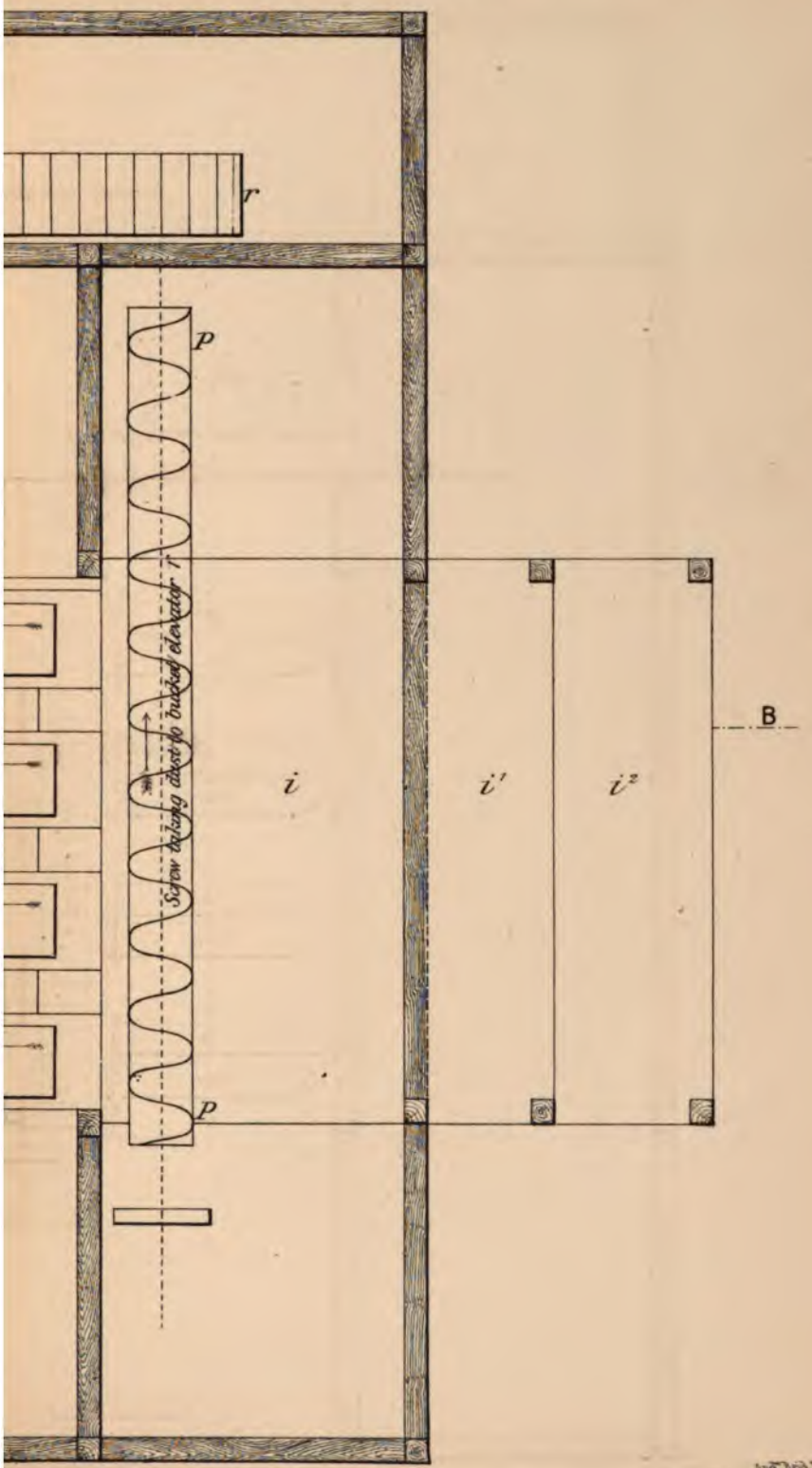
N C. D. Plate LIII.



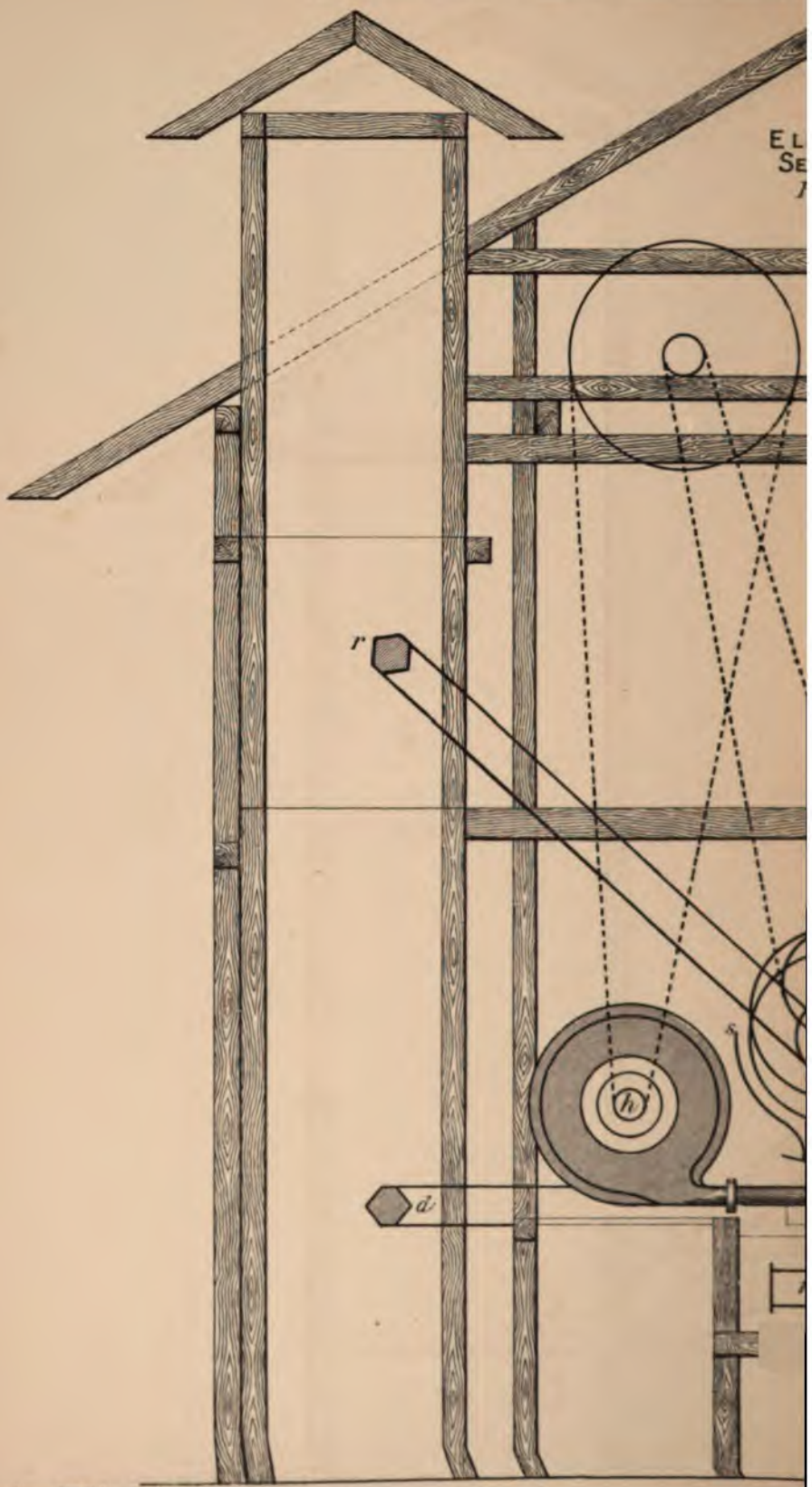
To illustrate Mr. E. P. Rathbone's paper



y, or wind, method of cleaning Coal.



To illustrate Mr. E. P. Rathbone's pape



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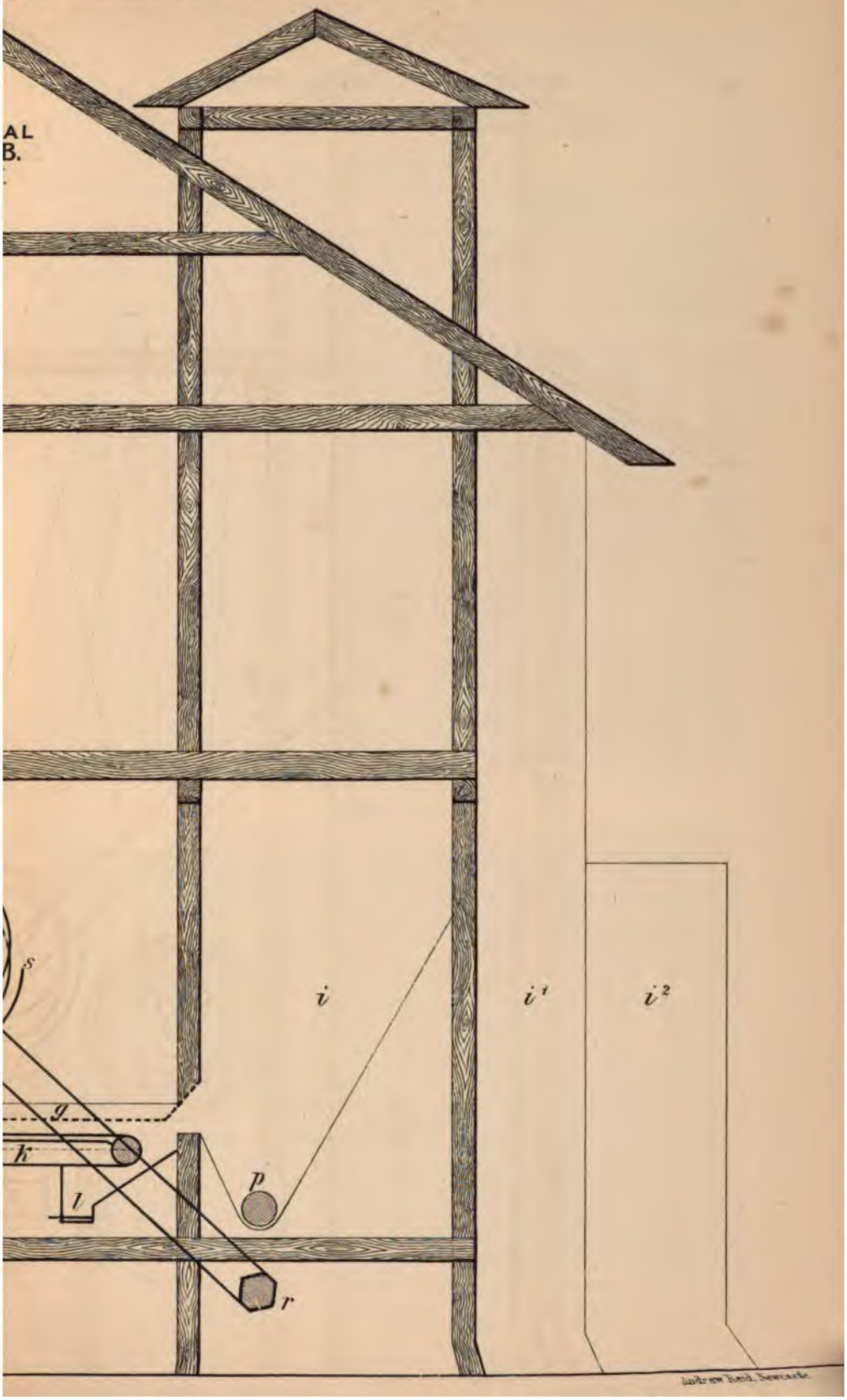


Andrew Reid, Newcastle.

BAROMETER READINGS, &c.

JULY, 1881.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·023	29·956	29·923	29·975	78·9	50·9	1	29·779	29·756	29·799	29·964	62·2	49·0
2	30·033	30·072	30·059	30·089	74·4	57·6	2	30·069	30·024	29·970	29·734	62·0	48·2
3	30·098	30·115	30·117	30·169	78·6	55·8	3	29·722	29·852	29·799	29·787	61·5	54·0
4	30·171	30·201	30·180	30·180	84·3	63·3	4	29·890	29·886	30·009	30·068	63·3	53·9
5	30·165	30·096	29·965	29·835	90·0	61·0	5	30·050	30·002	29·899	29·784	64·2	53·2
6	29·702	29·650	29·803	29·967	68·9	52·0	6	29·669	29·534	29·542	29·668	59·5	49·7
7	30·028	30·069	30·044	30·062	65·6	49·4	7	29·644	29·788	29·802	29·748	59·9	48·6
8	30·009	29·967	29·918	29·916	65·0	50·9	8	29·736	29·748	29·740	29·864	63·0	51·0
9	29·936	29·986	29·983	29·976	69·0	47·1	9	29·876	29·864	29·718	29·780	64·8	47·3
10	29·982	30·089	30·143	30·200	72·2	56·1	10	29·726	29·953	29·956	29·912	65·3	52·9
11	30·199	30·197	30·140	30·101	77·5	55·4	11	29·882	29·830	29·826	29·885	63·7	55·9
12	30·034	30·019	30·021	30·123	78·4	54·7	12	29·893	29·948	29·934	29·924	64·0	52·9
13	30·153	30·214	30·215	30·279	75·1	53·9	13	29·836	29·910	30·020	30·003	64·4	54·9
14	30·267	30·293	30·220	30·186	85·0	58·2	14	30·036	30·076	30·048	30·010	71·1	57·1
15	30·120	30·057	29·968	29·987	89·6	60·0	15	29·946	29·923	29·986	30·040	64·0	49·0
16	30·008	30·033	30·023	30·047	79·7	62·6	16	30·057	30·067	30·059	30·068	63·1	45·2
17	30·047	30·076	30·013	30·006	82·0	60·5	17	30·022	29·940	29·752	29·714	60·4	49·4
18	29·979	29·978	29·927	29·936	85·4	60·9	18	29·731	29·810	29·840	29·853	64·9	54·8
19	29·873	29·857	29·794	29·804	84·8	59·7	19	29·825	29·802	29·770	29·753	64·5	55·2
20	29·783	29·845	29·844	29·904	73·0	57·3	20	29·693	29·644	29·736	29·841	62·1	47·9
21	29·977	30·006	29·964	30·005	71·5	50·0	21	29·926	29·945	29·926	29·854	62·1	45·9
22	29·968	29·949	29·883	29·879	63·2	53·9	22	29·688	29·556	29·559	29·703	59·9	49·0
23	29·926	29·961	29·901	29·897	71·0	54·5	23	29·776	29·800	29·792	29·757	58·6	45·9
24	29·889	29·850	29·751	29·733	70·7	56·0	24	29·705	29·632	29·477	29·358	61·8	51·7
25	29·706	29·693	29·629	29·579	65·2	54·1	25	29·387	29·418	29·444	29·475	63·0	50·9
26	29·495	29·539	29·647	29·794	67·4	53·4	26	29·488	29·585	29·670	29·806	60·5	50·8
27	29·860	29·968	30·023	30·137	67·1	48·8	27	29·888	29·951	29·974	30·008	60·9	42·8
28	30·180	30·194	30·105	30·057	71·6	44·1	28	30·008	29·984	29·951	29·842	59·9	48·9
29	29·930	29·959	29·953	29·965	70·8	56·2	29	29·594	29·650	29·732	29·698	59·5	54·3
30	29·903	29·855	29·748	29·763	67·0	57·0	30	29·650	29·596	29·534	29·510	59·4	51·8
31	29·681	29·527	29·457	29·597	66·7	57·5	31	29·450	29·361	29·293	29·410	59·4	48·1

AUGUST, 1881.

1	29·708	29·781	29·758	29·853	71·1	49·9	1	29·520	29·655	29·750	29·860	60·0	45·0
2	29·970	30·082	30·105	30·179	72·1	54·8	2	29·935	29·973	29·922	29·842	65·0	40·5
3	30·195	30·220	30·227	30·267	69·5	51·1	3	29·848	29·836	29·920	30·038	63·0	54·0
4	30·271	30·304	30·227	30·200	78·6	57·6	4	30·064	30·048	30·038	29·968	69·7	52·6
5	30·125	30·046	29·912	29·910	80·5	51·8	5	29·830	29·722	29·650	29·641	66·2	54·9
6	29·967	30·071	30·113	30·169	71·1	55·3	6	29·636	29·781	29·917	29·942	62·2	52·3
7	30·164	30·127	30·028	29·969	71·0	49·9	7	29·820	29·793	29·650	29·523	64·3	54·9
8	29·895	29·805	29·708	29·521	72·3	53·0	8	29·550	29·583	29·500	29·452	63·3	54·7
9	29·486	29·574	29·712	29·822	69·1	54·1	9	29·500	29·578	29·618	29·662	63·0	50·4
10	29·805	29·795	29·733	29·903	67·5	54·2	10	29·628	29·543	29·542	29·699	56·4	48·3
11	29·989	29·996	29·837	29·826	68·2	50·1	11	29·727	29·724	29·690	29·750	60·5	48·6
12	29·835	29·783	29·639	29·579	60·8	51·9	12	29·722	29·652	29·584	29·566	59·2	46·9
13	29·603	29·662	29·704	29·738	58·9	48·0	13	29·522	29·537	29·578	29·649	60·2	49·1
14	29·731	29·794	29·823	29·857	62·2	53·6	14	29·650	29·690	29·723	29·754	63·4	50·4
15	29·851	29·851	29·804	29·720	62·5	52·9	15	29·722	29·712	29·664	29·626	62·3	49·0
16	29·645	29·610	29·503	29·461	67·2	55·7	16	29·567	29·523	29·450	29·404	56·0	53·2
17	29·420	29·437	29·430	29·423	63·7	55·1	17	29·334	29·324	29·344	29·414	55·9	51·0
18	29·412	29·586	29·705	29·767	66·5	53·5	18	29·450	29·526	29·570	29·610	61·4	46·5
19	29·704	29·530	29·446	29·642	66·1	52·0	19	29·532	29·429	29·326	29·408	53·0	47·3
20	29·761	29·898	29·911	29·909	65·1	48·5	20	29·538	29·656	29·734	29·767	60·1	44·8
21	29·793	29·743	29·726	29·817	62·5	47·1	21	29·720	29·708	29·692	29·743	60·7	43·9
22	29·831	29·851	29·824	29·840	66·0	45·6	22	29·750	29·785	29·746	29·786	62·2	43·9
23	29·768	29·706	29·602	29·524	68·4	55·2	23	29·768	29·740	29·674	29·602	55·4	49·0
24	29·521	29·649	29·723	29·835	64·3	51·4	24	29·508	29·554	29·614	29·674	55·0	49·9
25	29·812	29·714	29·545	29·421	62·5	51·5	25	29·660	29·556	29·300	29·078	55·1	49·7
26	29·339	29·406	29·446	29·556	66·9	53·0	26	28·835	28·966	29·237	29·432	54·9	47·5
27	29·628	29·709	29·768	29·889	62·3	48·2	27	29·542	29·630	29·692	29·746	56·1	42·0
28	29·963	30·065	30·084	30·129	63·7	43·1	28	29·778	29·842	29·840	29·898	54·0	44·2
29	30·062	29·992	29·930	29·875	62·2	50·3	29	29·874	29·855	29·814	29·848	57·0	39·4
30	29·736	29·786	29·813	29·948	65·4	52·2	30	29·908	29·994	30·076	30·166	57·4	44·0
31	30·037	30·121	30·139	30·189	56·5	49·7	31	30·202	30·250	30·254	30·335	60·0	37·9

BAROMETER READINGS, &c.

SEPTEMBER, 1881.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·167	30·165	30·146	30·178	55·3	48·8	1	30·326	30·333	30·298	30·365	62·2	39·1
2	30·141	30·125	30·083	30·093	60·1	50·3	2	30·330	30·314	30·270	30·260	55·9	43·2
3	30·040	30·015	29·959	29·960	62·6	49·8	3	30·200	30·155	30·095	30·097	60·3	49·3
4	29·906	29·890	29·835	29·829	63·6	47·5	4	30·028	30·010	29·978	29·974	55·9	50·3
5	29·764	29·727	29·613	29·546	60·3	50·9	5	29·896	29·840	29·743	29·665	58·9	48·8
6	29·450	29·514	29·536	29·541	65·1	54·0	6	29·516	29·438	29·396	29·423	55·8	48·3
7	29·521	29·617	29·675	29·727	65·0	52·0	7	29·420	29·481	29·532	29·613	60·1	50·9
8	29·723	29·715	29·699	29·754	63·7	47·7	8	29·614	29·663	29·670	29·758	59·4	49·8
9	29·779	29·859	29·873	29·963	64·7	49·9	9	29·812	29·895	29·946	30·060	60·9	50·9
10	29·971	29·988	29·981	29·988	57·5	48·2	10	30·102	30·143	30·102	30·124	61·8	49·8
11	29·951	29·944	29·923	29·961	58·5	51·9	11	30·093	30·095	30·042	30·062	59·2	48·7
12	29·950	29·978	29·989	30·035	59·0	54·0	12	30·054	30·056	30·012	30·016	57·1	50·1
13	30·045	30·095	30·073	30·094	63·6	51·5	13	29·980	29·994	29·984	29·994	57·5	48·4
14	30·083	30·103	30·069	30·094	64·6	47·7	14	29·988	30·010	30·010	30·052	56·8	46·5
15	30·075	30·108	30·084	30·147	64·1	46·1	15	30·054	30·114	30·084	30·132	58·9	41·5
16	30·161	30·196	30·131	30·132	64·2	40·4	16	30·122	30·142	30·090	30·058	59·3	44·6
17	30·059	30·027	29·913	29·842	65·2	44·7	17	29·923	29·827	29·704	29·668	57·1	46·3
18	29·705	29·669	29·583	29·649	71·3	54·0	18	29·561	29·563	29·574	29·626	53·6	50·5
19	29·709	29·805	29·833	29·894	66·0	51·4	19	29·628	29·687	29·700	29·744	58·3	49·3
20	29·862	29·823	29·702	29·577	68·2	49·1	20	29·708	29·692	29·592	29·534	62·3	50·3
21	29·419	29·418	29·447	29·475	63·4	52·3	21	29·418	29·366	29·346	29·408	59·0	53·3
22	29·493	29·585	29·626	29·665	60·0	48·5	22	29·212	29·626	29·624	29·870	55·3	50·0
23	29·796	29·924	29·995	30·101	59·5	53·3	23	29·974	30·033	30·038	30·058	55·5	50·5
24	30·127	30·160	30·133	30·110	65·3	55·0	24	30·034	29·918	29·900	29·848	55·9	50·3
25	29·997	30·021	30·007	30·057	68·3	49·4	25	29·881	29·897	29·856	29·782	59·4	44·9
26	30·045	30·052	30·087	30·156	64·2	47·5	26	29·814	29·894	29·928	29·982	59·9	48·3
27	30·144	30·176	30·141	30·212	61·4	47·0	27	29·995	30·066	30·088	30·157	58·7	47·0
28	30·229	30·302	30·307	30·368	61·9	42·1	28	30·156	30·212	30·204	30·227	58·3	48·2
29	30·361	30·391	30·322	30·355	63·0	39·7	29	30·171	30·134	30·090	30·070	60·0	51·9
30	30·333	30·368	30·312	30·317	62·1	39·4	30	30·110	30·210	30·220	30·256	60·9	53·7

OCTOBER, 1881.

1	30·279	30·256	30·194	30·197	58·9	39·1	1	30·247	30·257	30·200	30·237	62·3	48·5
2	30·152	30·145	30·106	30·123	57·9	43·1	2	30·200	30·218	30·156	30·167	57·9	42·1
3	30·105	30·132	30·138	30·176	57·9	43·3	3	30·160	30·171	30·154	30·208	57·6	40·9
4	30·166	30·182	30·162	30·161	53·5	39·1	4	30·224	30·273	30·250	30·298	54·3	45·0
5	30·127	30·157	30·206	30·263	47·4	34·0	5	30·274	30·289	30·304	30·362	50·6	39·2
6	30·226	30·241	30·294	30·393	54·2	35·0	6	30·380	30·432	30·404	30·416	53·0	38·2
7	30·423	30·475	30·440	30·364	52·6	46·3	7	30·360	30·358	30·300	30·268	53·0	46·0
8	30·216	30·052	29·906	29·852	48·0	44·6	8	30·192	30·181	30·090	29·968	55·4	43·0
9	29·806	29·810	29·767	29·868	52·3	44·0	9	29·726	29·617	29·610	29·698	51·7	42·0
10	29·952	30·032	29·996	29·930	56·2	39·1	10	29·654	29·614	29·600	29·372	55·7	42·8
11	29·786	29·731	29·727	29·789	61·7	49·1	11	29·266	29·324	29·374	29·416	56·0	42·7
12	29·832	29·803	29·757	29·725	56·9	45·7	12	29·408	29·408	29·414	29·426	51·1	38·6
13	29·722	29·839	29·798	29·535	56·6	44·0	13	29·444	29·560	29·480	29·185	48·4	38·2
14	29·233	29·080	29·156	29·657	58·7	44·5	14	29·596	29·510	29·201	29·550	44·0	36·0
15	29·853	29·911	29·985	30·146	49·3	35·1	15	29·662	29·806	29·998	30·142	45·5	33·8
16	30·240	30·364	30·364	30·391	48·0	30·0	16	30·220	30·292	30·258	30·248	44·9	30·5
17	30·381	30·392	30·325	30·328	52·4	25·4	17	30·170	30·150	30·114	30·127	52·0	36·6
18	30·279	30·270	30·197	30·200	52·0	33·8	18	30·106	30·121	30·084	30·128	54·6	42·0
19	30·163	30·149	30·045	29·976	48·5	36·2	19	30·141	30·182	30·108	30·113	49·0	41·0
20	29·886	29·808	29·677	29·611	50·4	40·1	20	30·034	30·035	29·924	29·846	50·4	46·3
21	29·563	29·609	29·595	29·594	48·7	44·4	21	29·798	29·798	29·756	29·748	48·3	45·2
22	29·511	29·380	29·254	29·259	51·6	46·6	22	29·614	29·584	29·485	29·418	48·0	44·1
23	29·308	29·393	29·435	29·505	52·3	48·7	23	29·424	29·438	29·650	29·717	47·9	45·0
24	29·539	29·628	29·670	29·696	49·0	45·7	24	29·731	29·780	29·820	29·870	48·6	43·8
25	29·708	29·773	29·809	29·890	50·1	39·5	25	29·925	29·987	30·024	30·082	46·0	40·9
26	29·957	30·052	30·005	30·169	49·1	39·2	26	30·116	30·214	30·258	30·335	47·0	40·0
27	30·173	30·205	30·189	30·219	46·0	37·4	27	30·343	30·358	30·306	30·278	44·4	38·6
28	30·193	30·177	30·105	30·086	46·5	37·0	28	30·208	30·190	30·180	30·215	47·3	36·2
29	30·074	30·104	30·123	30·194	44·6	35·6	29	30·236	30·343	30·350	30·364	42·4	34·6
30	30·203	30·219	30·199	30·225	44·0	32·5	30	30·328	30·306	30·228	30·194	42·2	30·4
31	30·202	30·185	30·089	30·033	39·8	27·5	31	30·118	30·048	29·900	29·764	42·3	31·0

BAROMETER READINGS, &c.

NOVEMBER, 1881.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·881	29·837	29·792	29·810	39·4	32·2	1	29·226	29·580	29·522	29·606	40·3	33·6
2	29·774	29·802	29·787	29·806	41·9	33·5	2	29·658	29·720	29·720	29·736	44·0	36·0
3	29·766	29·766	29·722	29·839	52·5	37·4	3	29·676	29·628	29·620	29·679	40·0	35·3
4	29·818	29·880	29·930	29·962	59·5	50·4	4	29·638	29·556	29·646	29·724	48·3	40·1
5	29·937	29·961	29·963	30·063	61·5	53·7	5	29·694	29·674	29·700	29·786	54·0	44·9
6	30·068	30·136	30·162	30·237	57·5	39·7	6	29·814	29·894	29·942	30·008	51·8	46·7
7	30·232	30·193	30·117	30·146	55·6	42·2	7	30·038	30·080	30·060	30·068	50·9	40·3
8	30·148	30·192	30·169	30·157	53·8	51·7	8	30·000	29·986	29·996	29·984	56·0	41·8
9	30·106	30·078	29·995	29·979	55·1	41·9	9	29·930	29·946	29·850	29·796	53·3	45·7
10	29·983	30·033	30·061	30·154	59·2	42·0	10	29·736	29·714	29·800	29·914	52·3	44·3
11	30·202	30·230	30·194	30·160	57·7	50·0	11	29·906	29·871	29·758	29·750	55·3	52·0
12	30·041	30·122	30·190	30·269	58·2	51·6	12	29·730	29·840	29·820	29·837	53·3	51·2
13	30·306	30·384	30·390	30·417	59·9	50·3	13	30·068	30·140	30·050	30·100	55·1	45·9
14	30·387	30·368	30·295	30·231	54·0	47·5	14	30·138	30·075	30·018	29·942	59·0	52·0
15	30·088	30·017	29·945	30·053	53·9	46·4	15	29·728	29·538	29·466	29·576	54·0	44·3
16	30·073	30·007	29·850	29·693	55·1	43·6	16	29·492	29·242	29·160	29·062	52·6	45·7
17	29·604	29·755	29·849	30·022	54·8	43·0	17	29·214	29·460	29·710	29·966	47·0	33·8
18	30·162	30·309	30·312	30·315	47·5	33·1	18	30·078	30·138	30·010	29·854	52·0	31·5
19	30·248	30·218	30·111	30·033	53·5	42·2	19	29·840	29·796	29·668	29·428	54·2	51·4
20	29·980	30·014	29·970	29·874	56·5	43·1	20	29·580	29·641	29·528	29·378	51·9	45·6
21	29·653	29·525	29·723	29·695	54·0	49·1	21	29·050	29·116	29·274	29·046	51·2	44·1
22	29·526	29·760	29·901	29·954	58·3	42·6	22	29·674	29·072	29·386	29·373	55·3	39·2
23	29·857	29·848	29·922	30·068	53·6	42·9	23	29·440	29·456	29·534	29·674	45·0	36·5
24	30·077	30·029	29·925	29·868	53·2	42·3	24	29·578	29·378	29·384	29·428	51·0	39·0
25	29·771	29·6s3	29·567	29·614	53·5	44·8	25	29·466	29·430	29·374	29·364	45·9	39·6
26	29·616	29·603	29·264	28·937	55·6	42·1	26	29·318	29·214	28·754	28·302	47·4	36·2
27	28·924	28·986	29·004	29·056	56·0	44·1	27	28·182	28·068	28·114	28·292	46·2	42·1
28	29·083	29·260	29·444	29·628	52·4	40·2	28	28·513	28·742	29·002	29·344	47·6	42·0
29	29·795	29·971	30·051	30·125	47·8	29·3	29	29·600	29·764	29·816	29·786	46·1	37·3
30	30·092	30·085	30·018	29·996	47·6	29·4	30	29·696	29·608	29·562	29·664	49·5	43·0

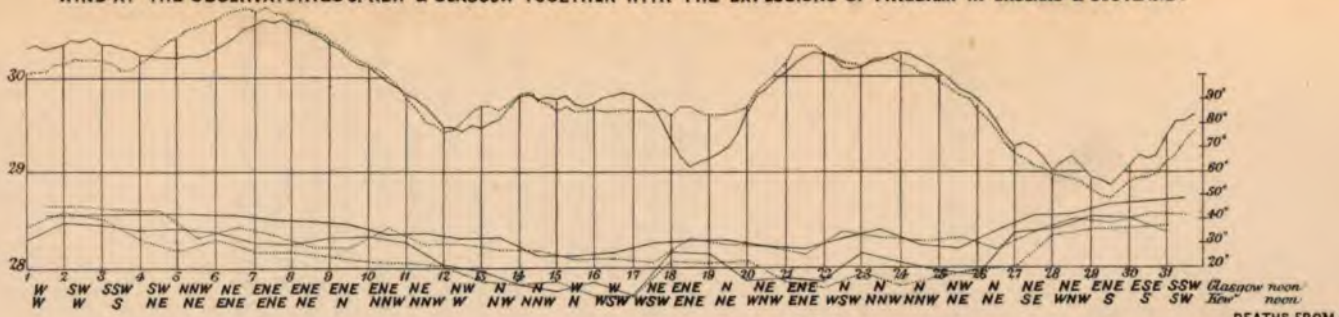
DECEMBER, 1881.

1	29·936	29·923	30·040	30·182	47·6	37·5	1	29·778	29·856	29·884	29·908	46·3	39·8
2	30·210	30·245	30·227	30·217	53·2	37·2	2	29·818	29·784	29·750	29·786	52·5	45·0
3	30·168	30·170	30·163	30·179	48·6	37·2	3	29·782	29·880	29·964	30·020	52·0	34·3
4	30·206	30·229	30·223	30·217	45·1	36·0	4	30·022	29·990	29·936	29·882	45·0	30·0
5	30·175	30·123	30·134	30·222	48·6	38·6	5	29·913	29·958	29·923	29·954	45·8	35·8
6	30·248	30·210	30·002	29·838	56·4	31·7	6	29·944	29·758	29·304	29·214	49·9	35·6
7	29·747	29·799	29·840	29·919	50·8	36·6	7	29·276	29·376	29·478	29·570	45·4	38·1
8	29·936	29·913	29·848	29·769	42·4	33·9	8	29·575	29·592	29·544	29·488	41·4	35·8
9	29·651	29·589	29·535	29·555	39·5	31·8	9	29·442	29·456	29·482	29·556	37·6	30·4
10	29·564	29·593	29·604	29·626	36·4	31·6	10	29·610	29·689	29·682	29·712	32·0	27·0
11	29·640	29·682	29·684	29·722	37·5	30·7	11	29·700	29·740	29·787	29·878	39·5	26·1
12	29·768	29·832	29·873	30·014	39·5	36·1	12	29·958	30·046	30·058	30·096	40·4	36·1
13	30·162	30·302	30·328	30·337	37·2	27·3	13	30·162	30·164	30·100	30·014	42·0	28·8
14	30·317	30·267	30·191	30·152	41·2	26·6	14	29·878	29·830	29·958	30·026	43·0	35·0
15	30·086	30·048	29·974	29·911	42·3	37·8	15	29·994	29·950	29·800	29·700	38·0	30·7
16	29·803	29·769	29·674	29·499	43·8	39·2	16	29·560	29·435	29·374	29·240	39·0	32·0
17	29·391	29·233	28·986	29·136	52·3	45·3	17	28·924	28·609	28·466	28·588	42·2	45·9
18	28·741	29·274	29·428	29·506	53·5	37·4	18	28·594	28·801	28·834	28·975	39·8	33·1
19	——	29·561	29·525	29·427	44·6	35·9	19	29·054	29·143	29·174	29·120	39·0	34·1
20	29·051	28·925	29·063	29·132	44·8	38·7	20	28·856	28·794	28·900	29·058	38·8	33·0
21	29·357	29·607	29·751	29·879	44·0	30·5	21	29·076	29·290	29·528	29·694	40·8	33·0
22	29·905	29·919	29·923	30·085	37·7	28·5	22	29·764	29·870	29·978	30·104	32·8	26·7
23	30·241	30·405	30·479	30·540	36·6	24·0	23	30·102	30·300	30·334	30·304	37·3	28·8
24	30·529	30·511	30·458	30·491	39·4	24·5	24	30·167	30·036	29·982	29·982	46·2	37·2
25	30·483	30·515	30·495	30·502	42·0	27·9	25	29·914	29·944	30·020	30·163	50·9	44·6
26	30·516	30·584	30·569	30·584	45·6	41·7	26	30·228	30·298	30·290	30·316	50·3	45·1
27	30·577	30·615	30·579	30·585	45·6	41·1	27	30·306	30·365	30·358	30·334	46·7	39·2
28	30·510	30·462	30·389	30·349	42·1	36·6	28	30·254	30·198	30·100	30·010	48·2	39·3
29	30·266	30·232	30·152	30·110	46·0	32·7	29	29·866	29·752	29·732	29·698	50·6	44·0
30	30·017	29·991	29·909	29·907	45·0	37·6	30	29·538	29·546	29·550	29·600	48·3	39·9
31	29·883	29·894	29·833	29·832	44·6	38·6	31	29·676	29·750	29·658	29·546	40·9	36·0

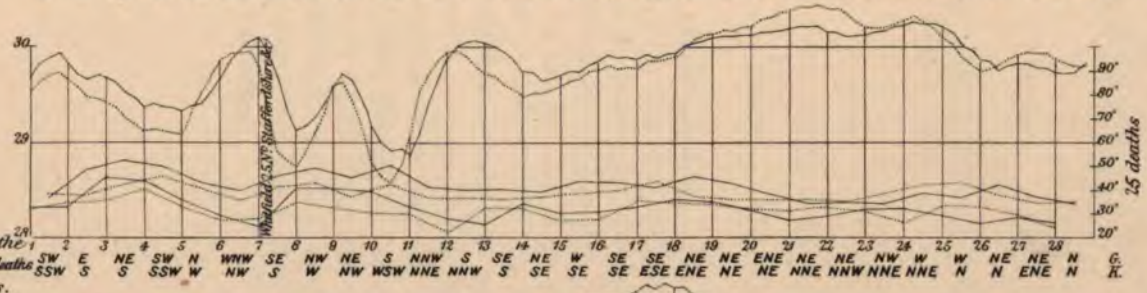
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1881

ANUARY.



BRUARY.

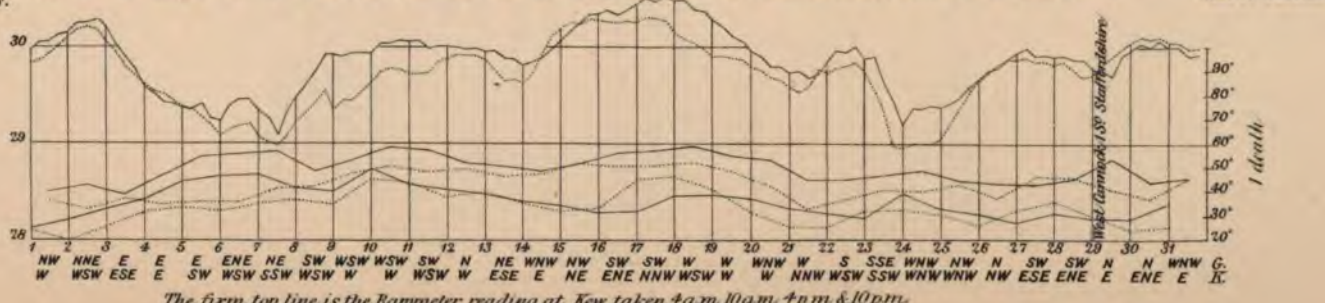


lines are firm
gow - dotted
figures attached to the
riots shew the N° of deaths
sed by the explosions.

DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1881

Northumberland &c.	0	deaths
South Durham	0	"
N. & E. Lancashire	2	"
W. Lancashire & N. Wales	55	"
Yorkshire	1	"
Midland	4	"
N° Staffordshire &c	38	"
S° Staffordshire &c	6	"
S° Western Monmouth &c	0	"
S° Wales	3	"
East of Scotland	2	"
West of Scotland	3	"
	114	

ARCH.



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The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.

Map N° E I of M&ME 1881-82

Andrew Reid, Newcastle

APPENDIX.

BAROMETER AND THERMOMETER READINGS FOR 1881.

BY THE SECRETARY.

THESE readings have been obtained from the observatories of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

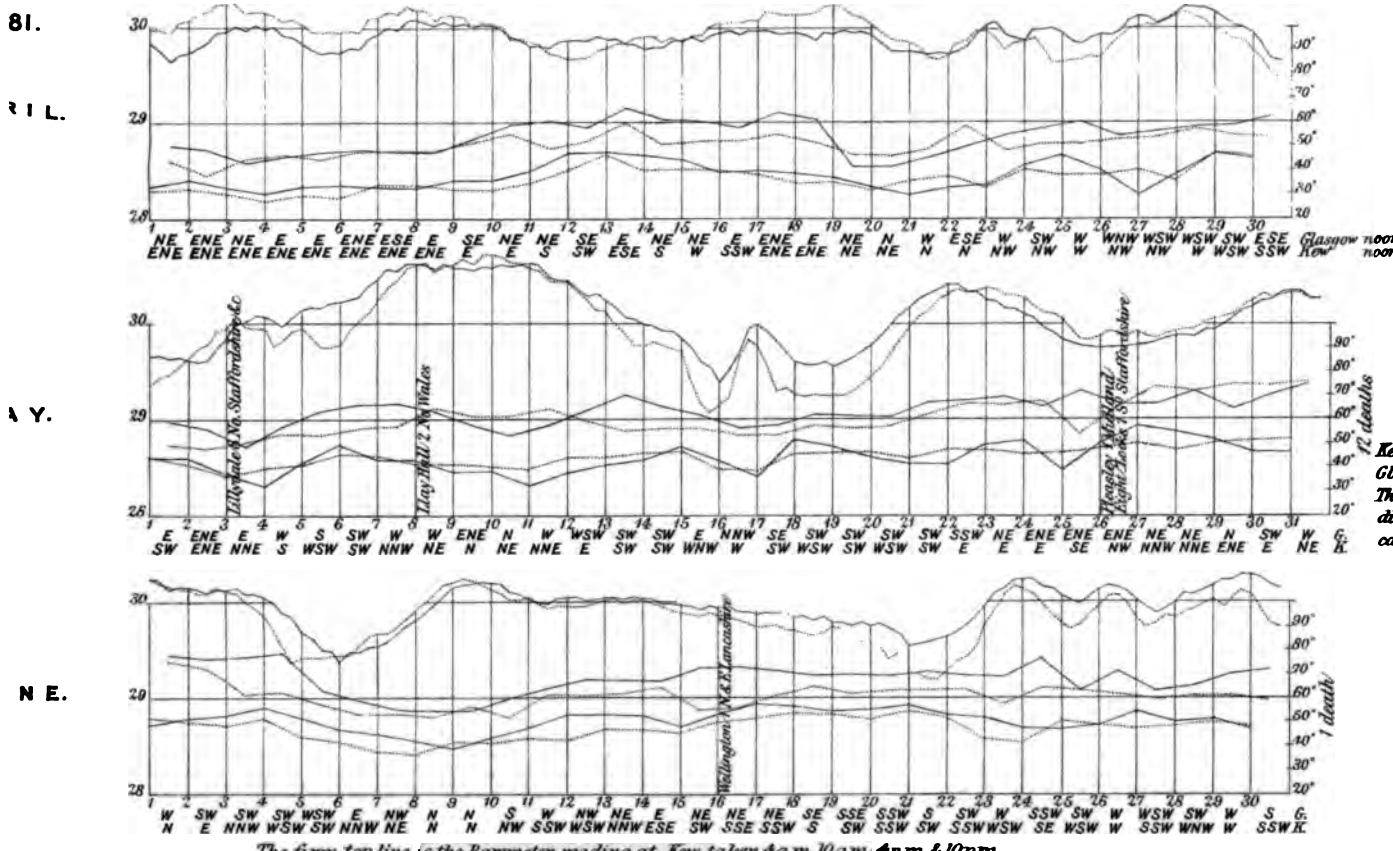
MAY, 1881.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Min mum.
1	29·657	29·661	29·628	29·639	59·6	42·9	1	29·366	29·410	29·442	29·532	48·7	43·
2	29·603	29·599	29·616	29·748	55·6	43·6	2	29·616	29·720	29·784	29·902	47·6	40·
3	29·843	29·945	30·007	30·073	48·4	36·2	3	29·944	30·084	29·964	29·939	50·3	36·
4	30·074	30·037	29·977	30·057	56·9	31·8	4	29·847	29·789	29·814	29·905	53·3	39·
5	30·124	30·180	30·167	30·207	63·3	40·2	5	29·942	29·851	29·767	29·759	53·5	40·
6	30·216	30·250	30·278	30·396	66·0	49·1	6	29·776	29·874	30·006	30·139	56·1	45·
7	30·461	30·560	30·549	30·602	66·4	43·2	7	30·257	30·364	30·489	30·589	56·9	44·
8	30·616	30·617	30·547	30·603	63·0	42·9	8	30·610	30·618	30·579	30·597	63·9	40·
9	30·585	30·580	30·548	30·586	56·9	38·0	9	30·638	30·667	30·616	30·706	61·2	41·
10	30·583	30·611	30·585	30·625	53·5	38·2	10	30·710	30·700	30·614	30·614	60·9	40·
11	30·626	30·604	30·491	30·473	58·0	32·5	11	30·576	30·548	30·488	30·458	64·2	38·
12	30·436	30·393	30·298	30·304	63·4	37·6	12	30·414	30·366	30·278	30·130	59·6	44·
13	30·232	30·183	30·038	30·024	70·5	40·1	13	30·126	30·016	29·876	29·788	55·3	43·
14	29·996	29·992	29·928	29·929	64·9	42·7	14	29·775	29·802	29·779	29·748	56·1	45·
15	29·853	29·767	29·600	29·512	61·1	48·6	15	29·608	29·406	29·142	29·066	55·8	46·
16	29·371	29·500	29·693	29·942	56·3	42·4	16	29·128	29·236	29·660	29·814	53·1	38·
17	29·998	29·946	29·821	29·711	57·5	35·8	17	29·767	29·546	29·297	29·310	53·0	38·
18	29·602	29·585	29·599	29·610	61·8	50·1	18	29·269	29·249	29·265	29·259	57·2	45·
19	29·555	29·603	29·647	29·723	61·0	48·3	19	29·225	29·256	29·299	29·366	56·4	45·
20	29·780	29·876	29·950	30·072	60·6	43·9	20	29·433	29·520	29·644	29·842	56·9	46·
21	30·176	30·276	30·302	30·370	67·2	41·2	21	29·978	30·090	30·164	30·246	61·8	44·
22	30·408	30·412	30·352	30·332	67·6	41·0	22	30·304	30·372	30·352	30·357	66·1	47·
23	30·257	30·226	30·172	30·146	69·6	49·4	23	30·380	30·361	30·290	30·307	66·1	47·
24	30·103	30·066	29·969	29·917	65·2	51·3	24	30·296	30·219	30·143	30·127	67·2	45·
25	29·833	29·804	29·772	29·781	72·1	38·4	25	30·045	29·922	29·850	29·867	53·7	46·
26	29·749	29·775	29·771	29·777	66·3	50·0	26	29·882	29·921	29·900	29·915	65·3	47·
27	29·771	29·808	29·823	29·869	66·0	57·0	27	29·910	29·890	29·854	29·899	70·4	49·
28	29·872	29·898	29·887	29·946	72·0	54·8	28	29·928	29·949	29·958	30·014	72·1	47·
29	29·947	29·991	30·046	30·131	64·5	51·7	29	30·053	30·099	30·106	30·205	74·6	50·
30	30·186	30·248	30·269	30·337	70·4	46·5	30	30·257	30·308	30·292	30·323	74·3	50·
31	30·344	30·354	30·273	30·269	76·1	46·5	31	30·341	30·313	30·278	30·270	74·9	52·

JUNE, 1881.

1	30·239	30·211	30·124	30·150	78·1	48·0	1	30·250	30·198	30·139	30·120	75·5	51·
2	30·139	30·123	30·087	30·120	76·3	50·7	2	30·118	30·080	30·092	30·128	72·0	49·
3	30·113	30·133	30·077	30·076	76·9	52·4	3	30·110	30·061	30·000	29·920	61·0	48·
4	30·047	30·004	29·865	29·817	78·2	55·9	4	29·827	29·717	29·514	29·382	61·8	50·
5	29·689	29·608	29·495	29·424	62·5	51·6	5	29·411	29·406	29·407	29·428	57·1	43·
6	29·394	29·450	29·450	29·515	59·0	46·6	6	29·430	29·454	29·544	29·630	53·2	41·
7	29·520	29·586	29·636	29·726	55·0	45·0	7	29·646	29·675	29·709	29·810	53·1	37·
8	29·787	29·877	29·961	30·081	55·0	42·0	8	29·900	29·981	30·068	30·154	52·3	36·
9	30·141	30·176	30·176	30·213	54·3	38·5	9	30·198	30·226	30·205	30·180	56·0	41·
10	30·197	30·178	30·096	30·062	59·4	43·0	10	30·122	30·064	30·012	30·012	51·1	40·
11	30·003	29·997	29·979	30·023	64·0	46·8	11	30·020	29·994	29·925	29·948	61·5	42·
12	30·025	30·043	30·005	30·016	67·2	52·9	12	29·957	29·958	29·954	30·000	60·3	42·
13	30·022	30·039	30·012	30·044	67·0	53·5	13	30·005	30·028	29·992	30·027	62·0	47·
14	30·029	30·027	29·969	29·976	66·4	52·7	14	30·008	29·977	29·885	29·900	63·9	46·
15	29·964	29·958	29·910	29·947	72·2	48·2	15	29·888	29·866	29·848	29·880	55·1	45·
16	29·932	29·934	29·891	29·893	73·0	53·5	16	29·869	29·852	29·813	29·786	55·9	49·
17	29·872	29·886	29·876	29·868	71·0	57·9	17	29·734	29·737	29·751	29·717	61·4	51·
18	29·837	29·841	29·804	29·821	68·9	57·1	18	29·693	29·650	29·633	29·682	64·2	53·
19	29·793	29·789	29·743	29·756	70·0	54·6	19	29·716	29·705	—	29·548	62·3	53·
20	29·747	29·762	29·739	29·677	69·2	55·4	20	—	29·507	29·400	29·461	63·5	51·
21	29·521	29·539	29·559	29·596	70·7	57·2	21	—	29·225	29·198	29·190	63·1	54·
22	29·623	29·661	29·728	29·861	69·0	53·5	22	29·288	29·372	29·405	29·509	63·1	50·
23	29·948	30·067	30·136	30·213	69·0	51·9	23	29·697	29·913	30·052	30·150	57·3	42·
24	30·234	30·211	30·148	30·141	76·1	47·5	24	30·128	30·064	29·995	29·864	63·9	41·
25	30·066	30·017	29·992	30·031	63·1	47·0	25	29·770	29·698	29·740	29·856	63·2	49·
26	30·107	30·167	30·146	30·115	70·1	48·6	26	29·951	30·033	30·038	29·974	61·4	48·
27	30·012	29·940	29·871	29·918	62·4	54·6	27	29·810	29·734	29·777	29·838	59·8	47·
28	29·984	30·054	30·071	30·133	65·1	50·0	28	29·838	29·871	29·912	29·964	61·2	48·
29	30·167	30·213	30·213	30·289	70·1	51·2	29	29·913	29·924	30·006	30·099	60·9	50·
30	30·292	30·267	30·177	30·119	71·8	47·4	30	30·070	29·906	29·770	29·724	58·9	48·

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



Kew lines are firm
Glasgow - dotted
The figures attached to the districts shew the No. of deaths caused by the explosions.

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
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Andrew Reid, Newcastle.

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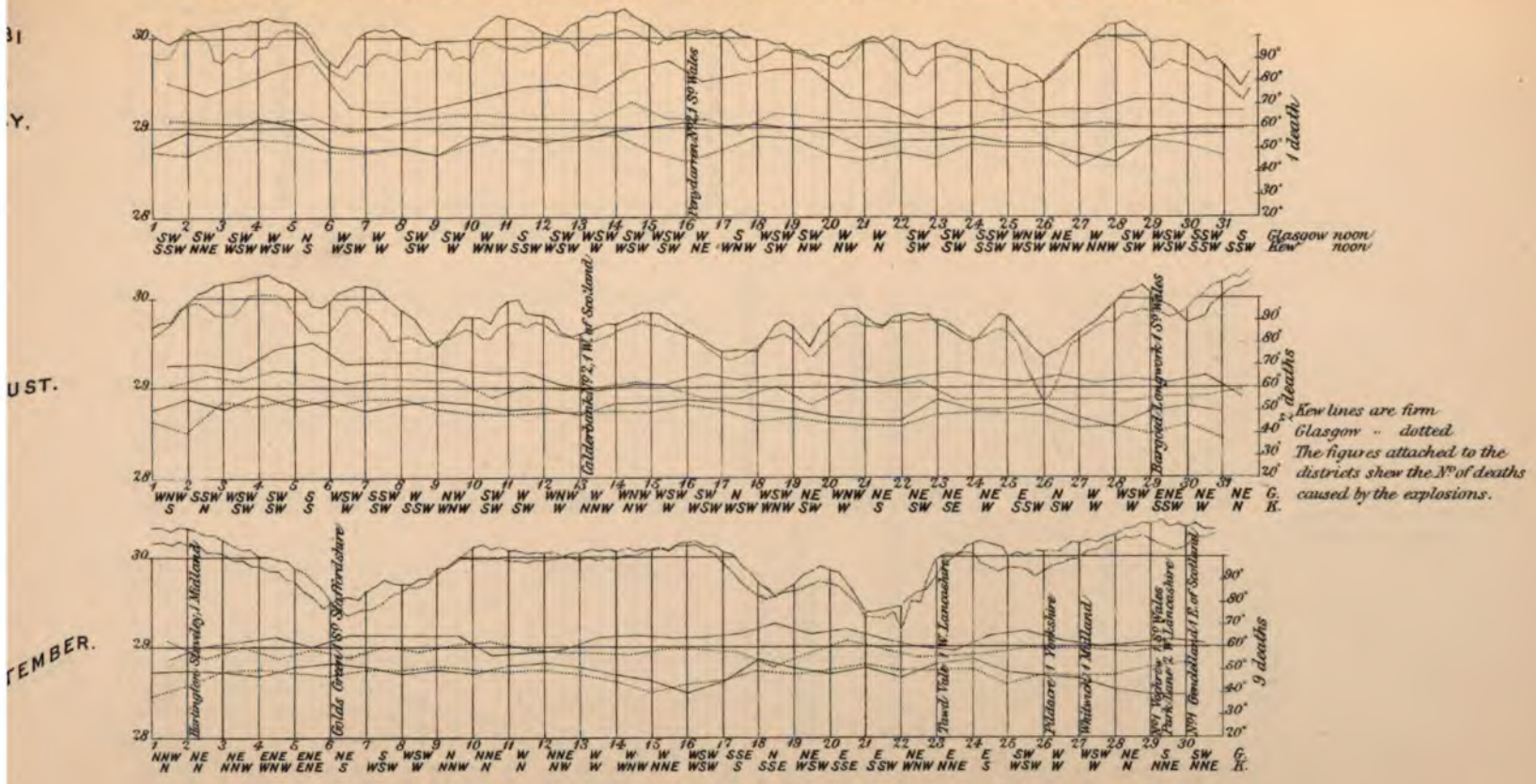

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Diagr. No. E.I. of M. & M.E. 1881-82

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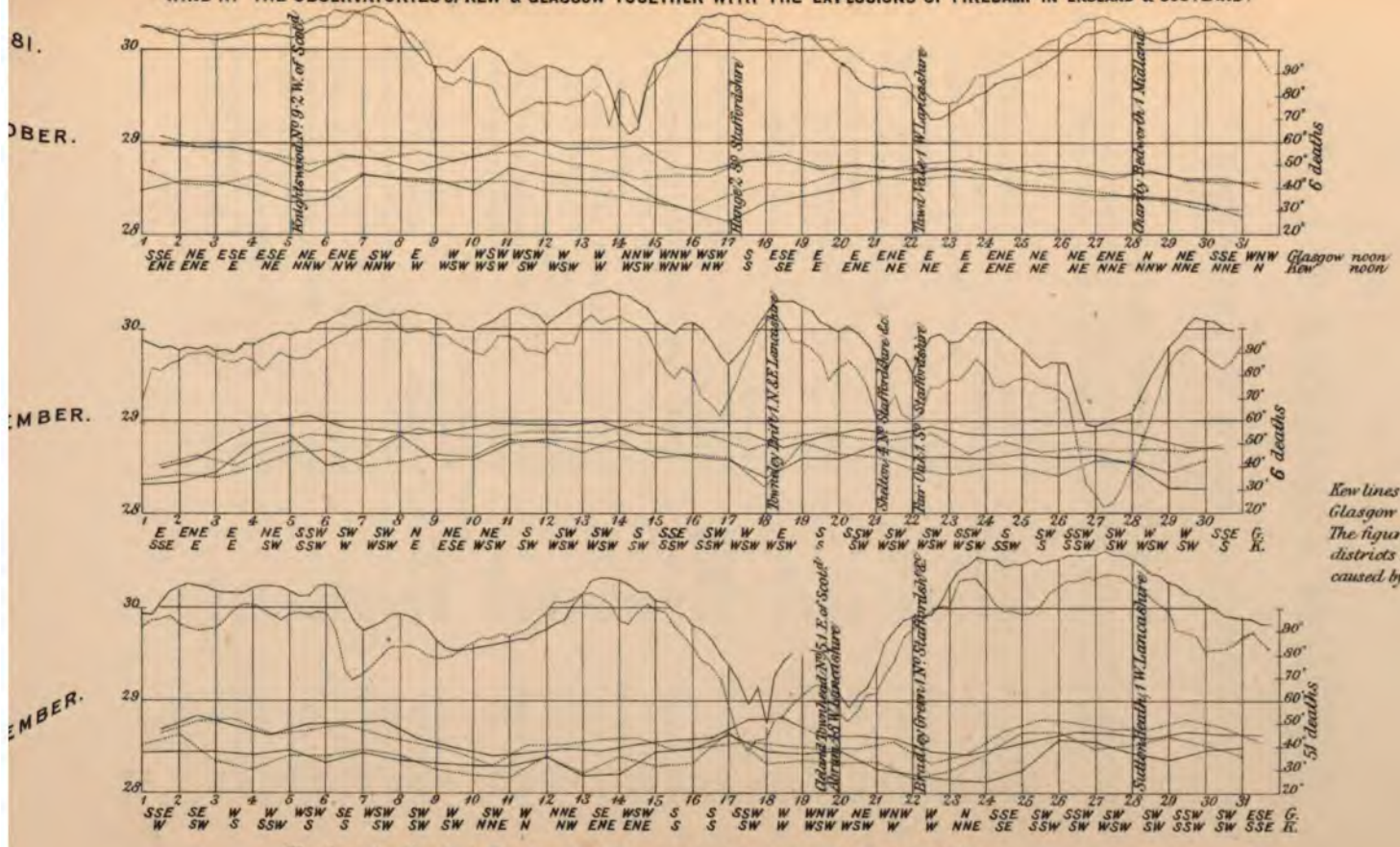

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Andrew Reid, Newcastle

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ABSTRACTS OF FOREIGN PAPERS.

THE MINING INDUSTRY OF PRUSSIA, 1880.

Die Bergwerks-Industrie und Bergverwaltung Preussens im Jahre, 1880. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen. Vol. XXIX., pp.* 459–492.

	1880.	1879.	Per Cent.
Coal.			
Production in tons	42,172,944	37,674,648	increase 11·94
Value at pit's mouth	£10,530,853	£8,744,640	do. 20·43
Average value per ton at pit's mouth	5s.	4s. 7½d.	do. 7·54
Number of mines at work	403	405	decrease 0·5
Persons employed	155,006	147,939	increase 4·78
Tons raised per man employed ...	272	255	do. 6·2
Deaths by accident	503	444	do. 11·04
„ per 1,000 employed... ...	3·222	2·968	do. 8·5
Men employed per death	308	333	decrease 7·5
Tons raised per death	84,042	85·044	do. 1·2
Lignite.			
Production in tons	9,874,888	9,278,354	increase 6·42
Value at pit's mouth	£1,508,288	£1,439,770	do. 4·76
Average value per ton at pit's mouth	3s. 0½d.	3s. 1¼d.	decrease 1·61
Number of mines at work	469	473	do. 0·8
Persons employed	19,757	18,593	increase 6·26
Tons raised per man employed ...	499	499	— —
Deaths by accident	42	40	increase 5·0
„ per 1,000 employed... ...	2·125	2·147	decrease 1·02
Persons employed per death ...	470	464	increase 1·3
Tons raised per death	235,116	231,959	do. 1·3
Total Fossil Fuel.			
Production in tons	52,047,832	46,953,002	increase 10·8
Value at pit's mouth	£12,039,141	£10,184,410	do. 18·2
Average value per ton at pit's mouth	4s. 7½d.	4s. 4d.	do. 6·7
Number of mines at work	872	878	decrease 0·6
Persons employed	174,763	166,532	increase 4·9
Tons raised per man employed ...	297	282	do. 5·3
Deaths by accident	545	484	do. 12·6
„ per 1,000 employed... ...	3·118	2·906	do. 7·3
Persons employed per death ...	306	344	decrease 11·0
Tons raised per death	95,500	97,010	do. 1·5

THE MINERAL STATISTICS OF THE KINGDOM OF SAXONY FOR THE YEAR 1879.

Statistische Mittheilungen über das Bergwesen im Königreiche Sachsen, 1879. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das jahr* 1881, *pp.* 1–202.

	Metalliferous Mines.	Coal Mines.	Lignite Mines.
Number of mines in 1879	268 ...	65 ...	141
Extent of mineral field in sq. miles ...	79½ ...	33½ ...	7½
Persons employed	7,832 ...	16,227 ...	2,609
Total employed, 26,668, and the population depending on these men equals 59,662.			
Output in tons	38,417 ...	3,310,613 ...	590,889
Tons raised per man per annum ...	4·9 ...	204 ...	227
Value of production	£241,990 ...	£1,130,644 ...	£91,188
„ per ton at pit's mouth	£6 5s. 10d. ..	6s. 10d. ...	3s.
Deaths per accident	9 ...	*133 ...	1
„ per 1,000 employed	1·15 ...	8·20 ...	0·38
Number of persons employed per death	870 ...	122 ...	2,609
		140	
Tons raised per death	4,268 ...	24,892 ...	590,889
		29,115	

* Figure high owing to an explosion of fire-damp in the Brückenberg Coal Mine on December 1st, 1879, by which 89 persons lost their lives.

C. Z. B.

THE RIVE-DE-GIER COAL-FIELD STATISTICS.

Statistique Résumée du Bassin de Rive-de-Gier. M. Meurgey, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1880, *pp.* 76–80.

The principal items are as follows:—

1.—Gross Drawings, Workmen Employed, Average Annual Drawings per Man, from 1873 to 1879.

Years.	Tons.	Workmen.	Tons.
1873 ...	1,017,000 ...	6,369 ...	160
1874 ...	754,000 ...	5,103 ...	148
1875 ...	738,000 ...	4,949 ...	149
1876 ...	792,000 ...	4,977 ...	159
1877 ...	753,000 ...	4,926 ...	153
1878 ...	732,000 ...	5,105 ...	143
1879 ...	723,000 ...	4,507 ...	161

2.—Workmen Below and Above-ground, and Mean Annual Drawings per Man.

Years.	Workmen. Below-ground.	Workmen. Above-ground.	Tons per Man. Below-ground.	Tons per Man. Above-ground.
1878 ...	3,469 ...	1,636	211 ...	447
1879 ...	3,126 ...	1,381	231 ...	524

4.—Average Yearly and Daily Wages in 1879.

	Below-ground.				Above-ground.			
	£	s.	d.	Fr.	£	s.	d.	Fr.
Yearly wage ...	51	7	0	(1,284)	39	2	0	(977)
Daily wage ...	0	3	8	(4·45)	0	2	9½	(3·38)

5 and 6.—Comparing one colliery with another, the number of tons produced by each workman in 1879 varied from 85 to 207 tons, and the number per hewer in 1878 from 0·8 to 9·9 tons.

7.—Number of collieries in 1879 was 37, and the average annual drawings per colliery 19,500 tons.

8.—Colliery Consumption.

Years.	Gross Drawings. Tons.	Colliery Consumption. Tons.	Proportion. Per Cent.
1878	732,000	74,400	10·2
1879	723,000	89,000	12·3

9.—Water Raised and Compared with Gross Drawings.

Years.	Water Raised. Tons (Cubic Metres).	Water Raised to Coal Extracted.
1873	3,833,000	3·8
1874	2,785,000	3·7
1875	3,333,000	4·5
1876	3,808,000	4·8
1877	3,060,000	4·1
1878	3,661,000	5·0
1879	4,601,000	6·4

10.—Comparing one colliery with another, the maximum ratio of water to coal (at Mouillon) was in 1878 15·8, and in 1879 17·4; the minimum (at Plat-de-Gier) was in 1878 0·16, and in 1879 0·15.

11.—Number of Accidents Below-ground.

Years.	Accidents.	Killed.	Injured.	Victims.
1873	40	13	30	43
1874	36	13	27	40
1875	34	13	25	38
1876	29	7	23	30
1877	25	8	21	29
1878	15	13	21	34
1879	16	4	12	16

12.—Proportion of Accidents to Number of Workmen and Thousands of Tons of Coal Extracted.

Years.	Number of Workmen for			Thousands of Tons Extracted for		
	1 Killed.	1 Injured.	1 Victim.	1 Killed.	1 Injured.	1 Victim.
1873	490	212	148	78	34	24
1874	393	189	128	58	28	19
1875	381	198	130	57	30	19
1876	711	216	166	113	34	26
1877	616	235	170	94	36	26
1878	393	243	150	56	35	22
1879	1,127	376	281	181	60	45

15.—Distribution of the Coal in 1879.

	Tons.	Tons.
Neighbouring works and P. L. M. Railway	300,000	
Department of the Rhône	200,000	
Do. Isère	52,000	
Do. Ardèche	50,000	
Do. Ain	8,000	
Do. Drôme	8,000	
Departments l'Est	16,000	
		634,000
Colliery consumption		89,000
		723,000

J. H. M.

THE HAINAULT COAL-FIELD STATISTICS.

Statistique du Bassin Houiller du Hainaut. M. Pinel, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1881, *pp.* 14–17.

The following statistics are taken from the Report of the Engineer-in-Chief, Director of the Mines of the Province:—

Years.	Drawings in Tons.	Average Selling Price per Ton. s. d.	Fr.
1870	10,196,530	8 10·27	(11·07)
1871	10,037,230	9 2·30	(11·49)
1872	11,616,166	10 11·23	(13·67)
1873	11,652,953	17 6·24	(21·90)
1874	10,698,130	13 6·04	(16·88)
1875	10,968,175	12 7·68	(15·80)
1876	10,486,660	11 0·86	(13·84)
1877	10,259,374	8 11·90	(11·24)
1878	11,003,423	8 1·53	(10·16)
1879	11,448,531	7 7·58	(9·54)

Drawings in 1879.

	Tons.
Steam coal	1,120,280
Semi-bituminous coal	5,965,845
Coking coal	2,201,386
Free-burning coal	2,161,020
Total	11,448,531

1.—Workmen Employed.

	1878.	1879.
Below-ground	56,383	55,893
Above-ground	17,277	17,974
Total	73,660	73,867
Average annual wage ...	£33 8s. 9d. (836f.)	£32 4s. (805f.)

2.—Working Cost per Ton.

	1878. s.	d.	Fr.	1879. s.	d.	Fr.
Labour	4	5·66	(5·59)	4	1·82	(5·19)
Other expenses ...	3	6·24	(4·40)	3	5·18	(4·29)
Total ...	7	11·90	(9·99)	7	7·00	(9·48)

3.—Drawings, etc.

	1878. Tons.	1879. Tons.
Coal	11,003,423 ...	11,448,531
Per working pit	56,428 ...	59,319
„ man below-ground ...	195 ...	205
„ „ above-ground ...	637 ...	637
„ workman employed ...	150 ...	157
Selling price	...8s. 1·536d. (10·16f.)	...7s. 7·564d. (9·54f.)

4.—Results.

	1878.	1879.
Fresh mines opened out ...	43 ...	40
Profits	£280,072 (7,001,800f.) ...	£239,934 (5,998,364f.)
Mines closed	46 ...	47
Losses	£246,272 (6,156,800f.) ...	£214,191 (5,354,780f.)
General profits	£33,800 (845,000f.) ...	£25,743 (643,584f.)
Profits per ton	0·672d. (0·07f.) ...	0·576d. (0·06f.)

Workpeople Employed in 1879.

BELOW-GROUND.

Men	41,866
Women over 21 years of age	1,162
„ between 16 and 21 years of age	2,793
Boys between 14 and 16 „	4,350
„ under 14 „	2,984
Girls between 14 and 16 „	1,602
„ under 14 „	1,139
Total	55,896

ABOVE-GROUND.

Men	12,296
Women over 21 years of age	685
„ between 16 and 21 years of age	1,507
Boys between 14 and 16 „	976
„ under 14 „	788
Girls between 14 and 16 „	885
„ under 14 „	837
Total	17,974

In 1870	the workmen	below-ground	wrought	191	tons.
„ 1871	„	„	„	188	„
„ 1872	„	„	„	206	„
„ 1873	„	„	„	191	„
„ 1874	„	„	„	174	„
„ 1875	„	„	„	178	„
„ 1876	„	„	„	174	„
„ 1877	„	„	„	180	„
„ 1878	„	„	„	195	„
„ 1879	„	„	„	205	„

The following table shows the comparison between the annual wage of the workman and the value of the coal produced by his work :—

Years.	Value produced per Man. £	s.	d.	Fr.	Annual Wage per Man. £	s.	d.	Fr.	Portion taken by Workman per 1,000 fr. produced by his Work. £	s.	d.	Fr.
1870	40	8	0	(1,010)	35	2	5	(878)	34	15	2	(869)
1871	40	0	10	(1,001)	34	0	0	(850)	33	19	2	(849)
1872	56	4	0	(1,405)	42	0	0	(1,050)	29	17	7	(747)
1873	88	3	0	(2,204)	56	4	9	(1,406)	25	10	5	(638)
1874	57	1	6	(1,427)	47	16	0	(1,195)	33	10	5	(83[illegible])
1875	52	4	9	(1,306)	47	3	2	(1,179)	36	2	5	(903)
1876	43	4	9	(1,081)	41	8	0	(1,035)	38	6	5	(958)
1877	33	15	2	(844)	33	6	5	(833)	39	9	7	(987)
1878	33	19	2	(849)	33	8	9	(836)	39	7	2	(984)
1879	32	11	2	(814)	32	4	0	(805)	39	10	5	(988)

Accidents in 1879.

Accidents in the Pits.		Accidents.	Killed.	Injured.
In descending or returning to bank	by the ropes	10	9	0
	" fixed ladders	1	1	—
	" man engines	1	1	—
By other causes		11	11	1
Falls of roof		55	50	6
Explosions		6	133	38
Powder		7	6	1
Asphyxia		4	6	—
On the inclined planes		14	12	3
Sundry accidents below-ground		19	17	2
" above-ground		12	12	—
Total		140	Victims 314	

1.—Per 1,000 Workmen Below and Above-ground.

Years.	Accidents.	Killed.	Injured.
1870	2·136	2·077	0·465
1871	2·865	2·453	0·416
1872	2·022	2·673	0·256
1873	2·124	2·275	0·415
1874	1·898	2·060	0·649
1875	1·662	3·088	0·322
1876	1·721	1·682	0·152
1877	1·522	1·442	0·240
1878	2·023	2·036	0·391
1879	1·895	3·493	0·758

2.—Per 100,000 Tons Drawn.

Years.	Accidents.	Killed.	Injured.
1870	1·44	1·40	0·31
1871	1·29	1·70	0·29
1872	1·28	1·69	0·16
1873	1·45	1·55	0·28
1874	1·42	1·54	0·48
1875	1·22	2·27	0·24
1876	1·29	1·27	0·14
1877	1·11	1·05	0·17
1878	1·35	1·36	0·26
1879	1·22	2·25	0·49

J. H. M.

COAL DUST AS AN ELEMENT OF DANGER IN MINING.

By the Rev. H. C. HOVEY. *Amer. Jour. Sc., Ser.* 3, *Vol. XXII., pp.* 18-20.

The results of Mr. Edwin Gilpin's investigation as to the part played by coal dust in spreading and augmenting an explosion, which took place in November, 1880, in the Albion Mines, Nova Scotia, are described.

The pit in question was 1,000 feet deep, and was ventilated by means of a Guibal fan capable of circulating 120,000 cubic feet of air through the ramifications of the mine. Except near the shaft the mine was very dry and dusty. The seam worked is 37 feet thick. On the morning of the explosion the mine was reported practically free from gas. An hour after, a first explosion took place at a considerable distance from the shaft of which the cause is unknown. Its result, however, besides being fatal to a number of men, was to drive huge volumes of coal dust into certain portions of the workings, some of the finer dust finding its way to the lamp cabin, and there, coming into contact with an oil lamp burning openly, a second explosion took place. The author remarks:—"Secondary explosions, caused by extracted or generated gas, are nearly always in the vicinity of the first one; but here is a case where the second was half a mile from the first, with an intervening space of at least a quarter of a mile known to have been free from flame, and presumed to have been free from gas, because men were in it with lamps which showed no indication of its presence." (Page 20.)

The author merely describes the facts without attempting to explain them.

G. A. L.

VENTILATING INSTRUMENTS.

Note sur les Appareils de Contrôle et de Surveillance de l'Aérage des Mines. Par M. L. AGUILLON, *Ingénieur des Mines. Annales des Mines, Sér.* 7, *Tome XX., pp.* 248-284. *Three folding Plates,* 5-7.

The author passes in review the various ventilating instruments under the heads of—

1.—Those for measuring the volumes of air.
2.—Those for measuring the ventilating pressure.
3.—Those for measuring the speed of ventilating machines.

With reference to the difficulty of measuring exactly the mean velocity of the air in a gallery, he quotes M. Morgue to the effect that "the ratio between the mean velocity and the velocity at any given point in the same section remains constant, whatever the variations of the mean velocity." It is only necessary, therefore, to find, once for all, the ratio between the mean velocity and the velocity at any one convenient point, and in future merely to measure the velocity at that point.

J. H. M.

THE PREVENTION OF EXPLOSIONS IN MINES CAUSED BY THE USE OF POWDER.

Notice sur un Procédé Propre à Prévenir les Coups de Feu Grisou Résultant de l'Emploi de la Poudre dans les Mines. Par OSCAR BUSTIN, *Directeur des Mines de la Société des Sarts, Ancien Élève de l'École des Mines de Liége. Rev. Univ. Mines, Sér.* 2, *IX., pp.* 491-508. *Four folding Plates,* 25-28.

The author points out that one-seventh of CO_2 added to the most explosive mixture renders it harmless, and he enters into the details of an arrangement for the injection of this gas into the board immediately before the firing of the shot.

From 1821 to 1879 the explosions that have occurred in Belgian mines may be divided, according to their causes, as follows. (Table taken from the Report of the Belgian Commission, page 209):—

Causes.	1821-50.	1851-79.	1821-79.
Naked lights	49	29	78
Opening of lamps	48	33	81
Rapid movement of lamps	5	5	10
„ currents of air	7	2	9
Defective lamps	17	32	49
Spontaneous combustion	1	1	2
Ventilating furnaces	18	1	19
Fires at bank	4	4	8
Unknown	21	15	36
Gunpowder	47	73	120
Total	217	195	412

It will be observed that not only is gunpowder credited with being the cause of the largest number of accidents, but that accidents from this cause are increasing.

J. H. M.

THE VELOCITY OF PROPAGATION OF EXPLOSIONS.

Sur la vitesse de propagation des phénomènes explosifs dans les gaz. Note de MM. BERTHOLET et VIEILLE. *Comptes Rendus XCIV., pp.* 101–108 *and* 822–823.

The experiments were made in open and closed tubes of lead caoutchouc and glass, 66 to 144 feet in length by $\frac{1}{2}$ to $\frac{3}{4}$ of an inch internal diameter (20·092 to 43·34 by 0·005 to 0·015 metres), straight and curved; under pressures varying from 22 to 63 inches of mercury (0·566 metre to 1·580 metres) and filled with mixtures of $H_2 + O$, $CO + O$, and $H_2 + O$ + air, with the following results, viz.:—The velocity of propagation of the explosion is not affected—by curves in the tube, by the material of which the tube is made, by closed or open end or ends, by the length of the tube, by the pressure, at least within the above limits, or by the diameter of the tube within the above limits.

The velocity is affected—by the diameter of the tube if very much reduced below $\frac{1}{4}$ of an inch. The result of the reduction being to decrease slightly the velocity of propagation.

By the composition of the explosive mixture, viz.:—

	Feet per Sec.	Metres per Sec.
$H_2 + O$	gave 9,366	(2,810)
$CO + O$	„ 3,630	(1,089)
Air + 45 per cent. of $H_2 + O$ ...	„ 4,796	(1,439)
„ + 40 „ „ ...	„ 4,170	(1,251)
„ + 35 „ „ ...	„ 4,016	(1,205)
„ + 32 to 5 „ ...	No explosion propagated.	

J. H. M.

THE PELZER FAN.

Ventilateur Pelzer. M. CLAMENS, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1881, *pp.* 175–177 *and* 236, *Plate XIV.*

This fan is on the screw principle, is of small diameter, but revolves at a high velocity. It is in use at several German and at one English mine.

No. of Experiment.	Colliery.	Diameter of Fan in		Revolutions per Minute of		Depression in		Velocity of the Air in		Volume of the Air in		Area of Drift where Air measured in.	
		Metres.	Feet.	Engine.	Fan.	Millimetres.	Inches.	Metres per Minute.	Feet per Minute	Cubic Metres per Minute.	Cubic Feet per Minute.	Square Metres.	Square Feet.
1	Wolfsbank.	2·5	8·2	17¼	114	8-10	0·31-0·30	300	934	720	25,430	2·4	51·66*
2				34	221	28-30	1·09-1·17	405	1,328	972	34,331	,,	,,
3				57-59	370-380	65-70	2·53-2·73	775	2,542	1,860	65,695	,,	,,
4				57-59	370-380	65-70	2·53-2·73	705	2,312	1,700	60,044	,,	,,
1	Général Blumenthal.	2·5	8·2	30	195	22	0·85	..	..	..	..	3·14	67·57†
2				40	260	40	1·56	..	..	..	..	,,	,,
3				45	292	52	2·02	..	..	..	..	,,	,,
4				57	331	64	2·49	..	..	..	..	,,	,,
5				56	364	78	3·04	..	..	..	..	,,	,,
1	Minister-Stein.	2·5	8·2	24	255	40	1·56	235	770	719	25,395	3·06	65·85‡
2				30	326	70	2·73	321	1,052	972	34,331	,,	,,
3				34	340	80	3·12	335	1,098	1,095	38,674	,,	,,
4				36	370	82	3·19	418	1,371	1,279	45,174	,,	,,
5				40	390	88	3·43	451	1,479	1,378	48,671	,,	,,
6				35	350	80	3·12	493	1,617	1,183	41,783	2·4	51·66‖
7				37	375	85	3·31	528	1,731	1,267	44,750	,,	,,
8				38	382	86-88	3·35-3·43	558	1,830	1,339	47,293	,,	,,
1	St. John, Stavely.	2·0	6·56	..	200-220 up to 450	51	1·98	..	..	1,076	38,004		

* The measures were made in the fan drift close to the fan.

† The workings only just begun and ventilated by means of columns of pipes.

‡ Measures taken in the fan drift close to the fan.

‖ Measures taken in a drift where there was a good deal of water falling from the roof.

J. H. M.

THE TRANSMISSION OF POWER BY ELECTRICITY.

Transmission des forces motrices au moyen de l'électricité. M. BAURE, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1880, *p.* 305, *and* 1881, *pp.* 154–156.

At a meeting of the Society, Central District, held on the 26th of September, 1880, a committee, consisting of MM. Baure, Courtin, Gaillard, Blanchard, and Durand, was appointed to consider the question, and, if possible, make practical trial of the transmission of power to long distances in mines by means of electricity.

At a subsequent meeting, 6th March, 1881, two members of the committee were deputed to assist at the experiments now being made below ground in the Loire Coal-field.

J. H. M.

THE TRANSMISSION OF POWER BY ELECTRICITY AT THE BLANZY MINES.

Transmission des forces par l'électricité. Application dans les mines de Blanzy à la mise en marche d'un ventilateur portatif. M. MATHET, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1881, *pp.* 104–107, *Plate IX.*

This is a description of an arrangement used for airing a stone drift.

The shaft was 550 yards deep and the drift 430 yards long, 980 yards in all; and the air had to be carried this distance in pipes 11¾ inches diameter (·3 metres).

The drift was first aired by means of a waterfall; but this was found insufficient, and the temperature at the face was 95° F. (30° C). A fan was then put into the drift, about 150 yards inbye, and driven by electricity, wires being taken down the shaft for that purpose. The fan is 2·6 feet diameter by 11¾ inches broad (0·8 × 0·3 metres), and at 730 revolutions per minute delivers 13·42 cubic feet of air (0·38 cubic metres) at the face. The temperature is now 89° F. (32° C.), at which the men can work for eight consecutive hours without fatigue.

When the Gramme machine at bank makes 1,200 revolutions that in the mine makes 700 to 800, yielding about 60 per cent. of the power.

COST OF THE INSTALLATION.

	£	s.
Portable engine of 10 horse-power	—	—
Two Gramme machines	120	0
Conducting cable, copper	21	0
Return cable, iron	3	15·64
Fixings for cable in shaft		14·4
Frames to carry Gramme and ventilator	2	1·88
Frames to carry Gramme and portable engine	7	4·0
Erecting	4	19·68
Shaft for engine	10	0
Total (4,244·25 fr.)	£169	15·6

If, instead of electricity, compressed air had been employed to drive the fan, the cost would have been:—

	£	s.
A portable 10 horse-power engine	—	—
A compressor, Saulter and Lemonier	349	6·0
Pipes	188	16·0
Elbows, etc.	0	14·4
Fixings in shaft...	3	0
Bolts and India-rubber rings	3	0
Erecting	12	0
Masonry and concrete	6	0
Shaft for engine and Compressor	20	0
Sundries	8	0
Total (14,700·50 fr.)	£590	16·4

More than three times the cost of transmission by electricity.

J. H. M.

ELECTRIC GIN, PÉRONNIÈRE COLLIERY.

Installation aux mines de la Péronnière d'une transmission électrique pour une exploitation en descente. M. CHAROUSSET, *Comptes-rendus mensuels. Soc. de l'Industrie Minérale,* 1881, *pp.* 230–235.

A steam engine of 32 horse-power drives a pair of Gramme machines, each 8 horse-power. The electricity is carried from these by four conductors, each conductor being formed of 16 No. 20 B.W.G (1 millemetre diameter) copper wires, to a pair of similar machines placed in the workings, 875 yards from the shaft bottom which is 437 yards deep. Total distance 1,312 yards (1,200 metres).

The bank up which the coal is drawn is 120 yards long, and dips 14½ inches per yard (·4 per metre).

The work done is equal to 5·2 horse-power.

During the month (up to 3rd December, 1881) the machine has been at work not a shift has been lost nor a tub stopped.

J. H. M.

APPARATUS FOR CLEANING COAL BY MEANS OF AN AIR-BLAST.

Note sur le nettoyage du charbon par vent soufflé par MM. BASIAUX ET LÉONARD, *Ingénieurs au charbonnage du Hasard, Liége. Rev. Univ. Mines. Sér.* 2, *IX., pp.* 135–139, *one folding Plate*, 13.

This apparatus has been invented and erected at the Rhein-Preussen colliery, by M. H. Hochstrale, the manager.

The coal is first separated by a trommel into five sizes. The fifth, which passes over the trommel and gives pieces from one to two inches (25–50 millimetres) in diameter, goes direct to the ovens. The others go each to a separate cleaner where the coal is spread out in a trough, about 6 feet 9 inches long by 2 feet broad, divided by a horizontal perforated iron plate into an upper and lower compartment. One end of the trough is in communication with the air-blast, the other with the cleaned coal dust chamber, from which, however, it is separated by a sloping screen, the bottom end communicating with a hopper placed below the trough. In the lower compartment of the trough is an endless band which carries the coal to be cleaned in a direction opposite to that of the air-blast.

The air-blast blows the pure coal dust through the screen into the cleaned coal dust chamber and the larger coal against the screen, down which it slides into a hopper, whilst the stones, too heavy to be affected by the blast, are carried on by the endless band into another hopper.

Result of an experiment made at the Rhein-Preussen colliery on 2,298 tons of unscreened coal:—

	Tons.	Per Cent.
1.—Large coal	608·7	26·5
2.—Nuts	492·9	21·4
3.—Stones	37·4	1·6
Total	1,139·0	49·5

	Tons.	Per Cent.
4.—Cleaned peas	504·6	22·0
5.— „ dust	514·1	22·4
6.—Stones from cleaners ...	140·3	6·1
Total	1,159·0	50·5

The washed coal gives 7 per cent. of ash and the stones 45 to 50 per cent. of coal. Note the great impurity of the one and the richness of the other.

The price complete for an output of from 500 to 600 tons per day is:—

	£	Francs.
1.—Buildings	260	(6,500)
2.—Coke ovens	240	(6,000)
3.—Engine and boiler, 25 horse-power ...	165	(4,125)
4.—Cleaners	700	(17,500)
5.—Leading? (transmission)	115	(2,875)
	1,480	(37,000)

The cost per month at Rhein-Preussen is:—

	£	Francs.
1.—Labour	26·15	(653·75)
2.—Materials	4·35	(108·75)
3.—Coal for boiler	5·00	(125·00)
4.—Sundries	12·00	(300·00)
	47·50	1187·50

Which, at 600 tons a day, is 0·79 pence per ton.

J. H. M.

NEW METHOD OF MAPPING THE ANTHRACITE COAL-FIELDS OF PENNSYLVANIA.

By CHARLES A. ASHBURNER, *Philadelphia, Trans. American Inst., M.E. Vol. IX., pp.* 506–518, *three folding Plates.*

These maps are being made by Government Geologists upon a scale of 800 feet to 1 inch, and will show

SURFACE FEATURES:—

1.—Railways.
2.—County roads.
3.—Streams.
4.—Outcrop of coal beds.
5.—Limit of coal measures.
6.—Towns, coal-breakers, &c.

UNDERGROUND FEATURES:—

1.—Contour lines, 50 feet vertically apart, of the most extensively developed coal seam.
2.—Area worked out and area being worked of the same seam.
3.—The workings of the same coloured.
4.—The workings of other seams coloured. Each seam being distinguished by a colour.

A map containing these facts will show:—

1.—Area of coal basins.
2.—Area of the individual seams worked out and under development.
3.—Area of the coal basins undeveloped.
4.—The structure of the basins where worked, with their rate of rise and fall in the centre.
5.—The amount of coal available at different depths.
6.—The most probable structure of the undeveloped areas.

J. H. M.

THE ROYAL MINING ACADEMY OF FREIBERG.

Die Konigliche Bergakademie zu Freiberg. Jahrbuch für das Berg-, und Hüttenwesen im Königreiche Sachsen auf das jahr 1881, *pp.* 203–220.

At this Academy there were, during the session 1880-81, 122 students, of whom 76 were German.

There were twelve professors for the following sciences and subjects:—Mining, Mineralogy, Metallurgy, Higher Mathematics, Chemistry, Mechanics, Geognosy and Palæontology, Metallurgy of Iron specially considered, Physics, Mining Laws, Mining Statistics, Surveying, and Geodesy.

Also, four extra teachers for Political Economy, Architecture, Hygiene, and Analytical Chemistry.

The students have access to three laboratories—Mining, Chemistry, and Metallurgy (iron specially)—and one workshop for the making of models.

A three to four years' course of study at the Academy completely educates students for the mining and metallurgical professions.

C. Z. B.

A SUMMER SCHOOL OF PRACTICAL MINING.

By HENRY S. MUNROE, *Adjunct Professor, School of Mines, New York City. Trans. American Inst. M.E., Vol. IX., pp.* 664–671.

Since 1877 the students have spent about a month each summer in practical work at one or more mines. For this purpose they are divided into squads of two or three men, and each squad is assigned to the care of a skilled miner, whom they assist to drill, hew, etc.

The experiment having proved successful, this summer class now forms a part of the regular course of study for the degree of mining engineer.

The details of the practical work are given in the paper.

J. H. M.

THE INDUSTRIAL SCHOOL FOR MINERS AND MECHANICS AT DRIFTON, LUZERNE, CO. PA.

By OSWALD J. HEINRICH, *Principal. Trans. American Inst. M.E., Vol. IX., pp.* 390–395.

This school was opened in May, 1879, for students over fifteen years of age. Instruction is given for two hours each evening, and at times, when the pits are closed, from 9–12 a.m. and from 2–5 p.m.

CLASSES.

1.—The Preparatory Class.—In this it is intended to admit boys under 15.

2.—The Junior Class.—English composition, book-keeping, mathematics, science, and geometrical drawing.

3.—The Senior Class.—Mechanical drawing, mining, and dressing of minerals.

4.—The Expert Class for graduates is under consideration.

The instruction is free, pupils providing only their books and materials; and the special object of the school is not to turn out young engineers, but to raise up intelligent foremen.

J. H. M.

PRUSSIAN ROYAL COMMISSION ON EXPLOSIONS IN MINES.

Commission zur Untersuchung und Prüfung der Sicherheitsmaassregeln gegen schlagende Wetter. Zeitschrift für das Berg-, Hütten- und Salinen-wesen. Vol. XXIX., pp. 32–63–70–83.

This Commission, which consists of 26 members, including the chairman (Dr. Serlo), commenced its sittings in June, 1881.

The Commission subdivided itself into three Commissions, one relative to statistics as to explosions in Germany and elsewhere, another as to Government regulations, and the third as to the scientific and technical bearings of the subject.

No official report has as yet been published except the programme, consisting of questions which are likely to have a connection with the subject.

C. Z. B.

THE FRENCH FIRE-DAMP COMMISSION.

REPORT TO THE MINISTER OF PUBLIC WORKS, 22ND JUNE, 1880.

Commission du Grisou. Rapport au Ministre des Travaux Publics. M. A. DAUBRÉE, *Ann. des Mines, Décrets, Sér. 7, Tome IX.*, 1880, *pp.* 225–231.

The Commissioners appointed MM. Aguillon, Le Châtelier, Petitdidier, Lallemand, Regnard, and Alfred Tresca, Sub-Commissioners. They have studied the following subjects:—

1.—Safety-lamps and questions bearing thereon. MM. Mallard and Le Châtelier have ascertained that fire-damp once mixed with air cannot be again separated. The temperature at which an explosive mixture will fire. The pressure caused by, and the velocity of propagation of an explosion. They have determined what lamps they think should be condemned in future. They have constructed a fire-damp detector from an idea of MM. Turquan Brothers, by which less than 1 per cent. of gas can be easily detected.

2.—Coal dust. Experiments are being made but there are no results published at present.

3.—Ventilation and anemometers. M. Vicaire has constructed an anemometer. M. Le Châtelier a very sensitive water-gauge. MM. Mallard and Le Châtelier have proposed an ingenious instrument by which the quantity of air passing into a mine can be ascertained at each instant.

4.—The chemical composition of fire-damp. M. Fouqué was appointed to enquire into this subject; but has been unable to give more than a portion of the results he had hoped to obtain.

5.—Life saving apparatus and physiological researches bearing on the matter. M. Regnard has made some interesting experiments in the Commentry mines. He proposes to submit a programme of observations which it would be desirable to have tried at the scene of an accident, this being the only way of testing their value.

6.—An abstract of the causes and circumstances of all the explosions of fire-damp that have taken place in France. There are 420 about which reliable information can be obtained.

7.—Colliery rules. M. de Souich has drawn up an abstract of the rules enforced in fiery mines both in France and in other countries. Based upon this MM. de Souich, Aguillon, and Pernolet have drawn up a set of rules which are being considered by the Commission who are now about to send out a set of rules entitled "Principles to be Considered in Working Fiery Mines," to the different collieries.

8.—The Commission has also examined proposals which have come to it from without, either through the Minister of Public Works or direct from the originators. In all sixty-four proposals have been examined.

J. H. M.

RULES FOR FIERY MINES.

Report of the Loire Committee.

Règlementation des mines à Grisou. M. Le Secretaire, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1880, *pp.* 201–234.

This paper contains:—

First.—A scheme of rules for the fiery mines of the Loire coal-field drawn up by the Loire coal-trade, and submitted to the French Fire-damp Commission, 6th April, 1880. The headings are:—

I.—Mines fiery throughout.
1.—Ventilation and general management.
2.—Safety-lamps.
3.—Gunpowder.
II.—Mines fiery only in parts.

Second.—A discussion, dated 9th, 16th, and 23rd September, 1880, by the Loire coal-trade of a scheme of "Principles to be Considered in Working Fiery Mines," drawn up and submitted to them by the French Fire-damp Commission. The headings are:—

Chapter I.—Ventilation and general management.
" II.—Gunpowder.
" III.—Lighting.
" IV.—Dust.
" V.—Sundries.
" VI.—Penalties.

J. H. M.

RULES FOR FIERY MINES.

Report of the North of France Committee.

Rapport présenté au comité des Houillères du Nord et du Pas-de-Calais par la commission nommée par lui. M. Le Secrétaire, *Comptes-rendus mensuels, Soc. de l'Industrie Minérale*, 1881, *pp.* 42–49.

This paper contains a scheme of rules for the fiery mines of the North of France and Pas-de-Calais coal-field, drawn up by the above coal-trade to be submitted to the French Fire-damp Commission. The headings are:—

a.—Ventilation.
b.—Lighting.
c.—Powder.
d.—Sundries.

J. H. M.

REPORT OF A COMMITTEE OF THE CHAMBER OF DEPUTIES ON THE COAL DUTY.

Rapport fait, au sujet de la houille, au nom de la commission de la chambre des députés chargée d'examiner le projet de loi relatif à l'établissement du tarif général des douanes—par M. Louis Legrand, *Ann. des Mines, Décrets, Sér.* 7, *Tome IX.*, 1880, *pp.* 69–79.

The Committee state reasons for and against the duty on foreign coal (about 1s. a ton), and decide in favour of retaining it.

They quote a great many statistics of which the following are a part:—

In 1878 there were 629 concessions, but only 357 pits at work.

The produce, etc., is now, in round numbers:—Produce, 17,000,000; consumption, 24,500,000; export, 600,000; import, 8,000,000.

More than four-fifths of the produce comes from six coal-fields:—Valenciennes (North of France, etc.), the Loire, Alais, Creusot and Blanzy, Commentry, and Aubin. The remainder from 41 small distinct basins.

Of the imports more than 4,000,000 tons come from Belgium, principally to the department of the North, also to those of the Seine, Meurthe and Moselle, Aisnes, and Ardennes. From England 2,750,000 to the departments lying near the coast, principally Seine-inférieure and Algeria. From Germany 1,000,000, principally to Meurthe and Moselle.

	Men Employed.	Wages per Year. Francs.	Wages per Year. £	Wages per Year. s.	Tons per Man per Year.	Price at Pit. Francs.	Price at Pit. s.	Price at Pit. d.
1833	15,400	...	...		...	10	8	0
1852	...	...	...		...	10	8	0
1873	...	...	...		...	25–30	20–24	
1875	...	1,058	42	6	...	...	...	
1876	110,802	...	...		154	...	...	
1878	106,415	975	39	0	159	13·46	10	9

Before 1860 the duty varied from 11·52d.—2s. 10·56d. (1·2—3·6 fr.) per ton, according to the kind of coal and the place from which it was imported.

Cost of Transport.

The Southern Railway of France charges 0·288d. (3 centimes) for English and 0·48d. (5) for the coal from Aveyron and Carmaux.

The Northern carries to Paris for the same price per ton, viz., 5s. 11d. (7·4 fr.), English coal from Dunkirk, 190 miles, Belgian from Quiévrain, 164 miles, Native from Lens, 131 miles.

The Western charges 4s. 11·6d. (6 fr.) from Dieppe to Rouen, 125 miles, 5s. 11d. (7·4 fr.) from Lens to Rouen, 127 miles, 6s. 7·6d. (8·3 fr.) from Lens to Reims, 139 miles, 5s. 3·8d. (6·65 fr.) for Prussian coal from Batilly to Reims, 114 miles.

The production per man per year is:—

In England 333 tons.
„ Prussia 200 „
„ Belgium 180 „
„ France 154-159 tons.

The cost of production in England is 5s. 3·4d. (6·5 fr.) per ton, whilst in France it is 8s. 9·6d. (11 fr.)

J. H. M.

A BUREAU OF MINES AND MINING, ETC., IN THE UNITED STATES.

The Engineering and Mining Journal, 21st January, 1882.

Details of a Bill introduced by Mr. Belford, of Colorado, in the House of Representatives, and referred to the Committee of Mines and Mining.

Section 1.—	Relates to the establishment of a Bureau of Mining.		
Do. 2.—	Do.	do.	Manufactures.
Do. 3.—	Do.	do.	Labour Statistics.
Do. 4.—	Do.	do.	Commerce.

J. H. M.

REPORT ON BREAKAGE OF COLLIERY ROPES.

Rapport fait au nom de la Commission chargée par M. le Ministre des Travaux Publics d'étudier les Questions concernant la Rupture des Cables de Mines. Par M. L. AGUILLON, *Ingénieur des Mines. Annales des Mines, Sér.* 7. *Mémoires, Tome XX.*, 1881, *pp.* 373-497.

OBJECT OF THE REPORT.

The Minister of Public Works appointed, on the 30th May, 1878, a Commission to report on wire ropes where men ride.

FIRST PART.—ROPES IN USE IN FRANCE.

I.

The Commission deal specially with winding ropes, and divide these into fibre (or textile), iron-wire and steel-wire ropes.

Most of the coal-fields and salt mines employ textile, the iron mines principally wire ropes.

In 1879 only nine pits in France had steel winding ropes, although steel is frequently adopted in hauling; galvanized ropes in two lead mines and one sinking pit.

II.—TEXTILE ROPES.

The Commission recommend the use of Manilla in wet shafts, and hemp in dry shafts, taking the precaution to have the hemp ropes saturated with tar or vegetable oil. They conclude that textile ropes are not free from unexpected ruptures similar to those usually attributed to wire ropes.

III.—IRON-WIRE ROPES.

In France the usual wire employed is from No. 12 (·0705 in. dia.) to No. 18 (·134 in. dia.), Paris wire gauge, for round ropes, and No. 13 (·0752 in. dia.) to No. 15 (·0843 in. dia.) for flat ropes. Of these No. 14 is the most usual.

Round ropes are in two distinct groups—those in which the core of the strand has a single series of encircling wires, and those in which there are two concentric series, the wires being 6 to 8 in each strand in the first type, and 18 to 23 in the second. The number of strands varies from 5 to 8 and reaches 9 in the Rive-de-Gier district.

Flat ropes have 4, 6, or 8 cables of 4 strands each (sometimes 6), each strand composed of 6 to 11 wires. The stitching is made with soft wire, occasionally galvanised. Double stitching is not recommended.

Taper round ropes are not described, but the taper flat ropes are made similarly to those in use in England.

The resistance of a rope, compared with that of the accumulation of individual resistances of the wires, is nearly identical.

Alteration by Wear.—On first starting ropes usually stretch 1 to 2 per cent., and sometimes a further stretching occurs when nearly worn out. But the wearing and flattening of the wires, and the appearance of occasional broken wires, are the best signs of limit of work. The molecular alteration of the wires is much disputed, but it is clear that by constant vibration the iron becomes more brittle. The conclusions arrived at by the Commission being that a new and an old rope vary in the proportion of 100 to 55 (or 45 per cent.); and, further, that whereas in a new rope the comparative strength of individual wires only differs by 13 per cent., in a worn rope it approaches 75 per cent.

In flat ropes the results are still more striking, the wires would not after use even stand one bend in the vice, which is partly attributed to the cutting action of the stitching wires.

The ultimate conclusions derived by the Commission are that ropes, after a certain period of actual work, may give way, without external notice, especially when continuous and sudden jerks are taken into account.

Load.—The Commission state that the best firms only load their ropes to one-tenth of the breaking strain; but in small ropes of good wire, where each wire has its own share of work, this is occasionally increased to one-sixth.

Wear due to folding on Drums or Pulleys (Minimum Diameter).—No direct experiments have been made, but the recommendation is a minimum of 10 feet pulleys and 13 feet drums.

Angle between Pulleys and Drum.—All makers endeavour to diminish this as far as practicable, and to have a direct lead from pulley to drum.

Springs or buffer shackles are after trial abandoned.

Splices.—The same remarks apply as to those in textile ropes, except that even more care should be used.

Pulleys are recommended to be cleaded with wood, especially in flat ropes.

Keep of Ropes.—Oxidation being one of the principal causes of failure and wear, it is important to keep the ropes greased. Acid oils should be avoided.

IV.—STEEL ROPES.

The Commission admit that the experience in France is not sufficient to generalise, but they state that experiments have shown that the wires of broken or worn steel ropes had lost all flexibility.

V.—REMARKS APPLICABLE TO ALL THE PRECEDING SYSTEMS.

These may be summarised by stating that the Commission found that a system of mutual confidence was usual, employers and makers trusting each other. In some districts, especially in the "Nord," a system of guarantee similar to that in use in Belgium is enforced.

Winding Men.—The inquiries show that safety-cages are not universal, that men are preferably changed on the newest rope, and that less speed and more caution are used in these circumstances.

The Commission recommend that a daily register of every winding rope should be kept.

VI.—WIRE-ROPE GUIDES.

The statistics collected by the Commission are without data or interest, except that no loss of life has resulted from their employment, although frequent breaks are reported.

VII.—INCLINED PLANES.

VIII.—GENERAL USE IN AERIAN ROADS, ETC.

SECOND PART.—ROPES IN USE ABROAD.

I.—BELGIUM.

Flat Hemp and Manilla Ropes are generally adopted on the grounds of safety and facility in counter-balancing at great depths, owing to their considerable thickness; safety-cages being only compulsory where metallic ropes are used.

Manilla Ropes.—These are made taper in deep pits; a good example being at Sacré Madame, 900 metres (984 yds.) in length tapering from 315·5 millimetres (12½ ins.) to 193·37 millimetres (7½ ins.), weight of rope 8 tons, weight of load 6½ tons including 2¾ tons of coals. Guarantee by maker, 30 months work or 120,000 tons of coals. Water alone is used as a preservative.

Iron Wire Ropes are even rarer in Belgium than steel, working oad one-seventh of their breaking strain, the wires being about 13 or 14 B.W.G.

Steel Ropes are not common, but are employed at Mariemont, Bascoup, &c.; wires, 14 or 15 B.W.G. At Seraing round steel wire ropes are used, very flexible, composed of 6 cables each, 5 strands of 6 wires, No. 14 W.G.

Guarantee.—A regular system of maker's guarantee exists of from 18 to 24 months wear, a fine of one-twelfth to one-twenty-fourth of the value of the rope being deducted for each month short of the guarantee.

In the Hainaut district in changing men the following conditions are compulsory:—

Safety-cages and safety-hooks.
Maximum fixed number of men to ride.
Weekly examination by special officers.
Register of each rope.

II.—ENGLAND.

It may be said that textile winding ropes are now unknown in England. Iron and steel-wire ropes, round and flat, being exclusively used. Wires are divided into charcoal iron, Bessemer crucible and plough steel. The usual wires are Nos. 11, 12, and 13 B.W.G.

The Commission classify as follows the causes of the success of metallic ropes in England:—

1.—Careful manufacture with selected wire.
2.—Effective examination.
3.—Careful preservation.
4.—Large diameters of winding drums and pulleys.
5.—Care in winding and small number of decks.
6.—Skill of enginemen.

III.—GERMANY.

Although textile ropes are occasionally met with, the usual materials are iron or steel, especially the latter.

Tests are general, both by makers and users, and are classified:—

1.—Breaking strain.
2.—Stretching due to strain.
3.—Flexibility.
4.—Torsion.

The iron wire is principally obtained from Westphalia and Saarbrück, and the following is a Table of the number of bends, at an angle of 90 degrees, requisite to break the wire in a vice with jaws one-fifth of an inch radius:—

B.W.G.	11	12	13	14	16	17 and 18
No. of bends	4 to 6	5 to 7	5 to 7	7 to 8	8 to 9	10 to 12

English steel wire is preferred to the home-made, and the following bends are required:—

B.W.G.	11	12	13	14	16	17 and 18
No. of bends, as above	4 to 6	4 to 7	4 to 8	7 to 9	9 to 11	12 to 16

The price of steel is not quite double that of iron, while the work is more than twice in favour of steel.

The proportion of working load to breaking strain is one-eighth to one-ninth.

Men are only allowed to ride in coal-drawing shafts after examination and by special authority from the Government officials. D. P. M.

TESTING ROPES AND SOCKETS BY HYDRAULIC POWER.

Hydraulische Presse zum Zerreissen ganzer Drahtseile auf der Königl-Steinkohlengrube Friedrichsthal, bei Saarbrücken. Von HERRN BAUMANN, *Zeitschrift für das Berg-, Hütten- und Salinen-wesen. Vol. XXIX., pp. 57–64. Plate V.*

The hydraulic press consists of a vertical cast-iron stand, at the top of which is a hydraulic press, the plunger of which works upwards, and by means of side rods, which can be lengthened and shortened, moves a crosshead below, to which is attached one end of the rope to be tried, the other end being held in the bottom part of the frame. The rope is fitted at both ends with sockets, and, necessarily, the efficiency of the sockets was tested with the breaking strain of the ropes, for everything depended upon the rope being held tight to prevent slipping when under strain.

Ten different sorts of sockets were tried, briefly described as follows:—

No. 1, Baumann's patent, which consists of three wedges acting upon a hard patent metal cast round the rope, and which are held together by a box, in the inside of which the wedges move in grooves. The rope is thus held by these wedges, which act indirectly through the metal; and to the circular box enclosing the wedges, metal and rope, the weight to be carried by the rope is attached, the circular box being so made that the heavier it is weighted the tighter it drives the wedges, thus securing the rope.

Nos. 2 and 3 sockets are on the same principle, except that the wedges act immediately upon the rope without their being protected by patent metal. No. 2 is for round ropes and No. 3 for flat ones. Nos. 4, 5, and 6 are similar to the ones generally used in England, the wires at the end of the rope being unravelled and turned; in No. 4 is a conical ring, the whole being enclosed in a conical box, the ring acting as a wedge in keeping the wires tight against the rope and the encircling box.

In No. 5 a round wedge-shaped pin is driven into the end of the rope after the wires have been turned over and the whole encircled by a conical box.

No. 6 has molten lead or zinc cast over the end of the rope after the wires have been turned over, the whole being covered with a conical box like the rest.

In Nos. 7, 8, and 9 the rope is bodily bent over a ring, forming a loop, the end being fastened to the rope in No. 7 by rings which are made to fit tight by being hammered to fit when in place; and in Nos. 8 and 9 by three sets of clamp plates, which have rough and hardened edges, held by two bolts to each clamp in No. 8 and four bolts in No. 9.

The ropes tested were made by G. Heckel, of Saarbrücken, not made for the trial, but were spare ropes at the colliery where the experiments were made.

They were all of steel, two being round and one flat. No. 1 was 1·1 inch in diameter, and was composed of seven strands, each having a hemp core 0·39 inch diameter. Each strand had seven wires 0·09 inch diameter. The total area of metal was 0·377 square inch. The breaking weight, when new, was guaranteed by the maker to be 62,000 lbs., and in being tested proved to be equal to 70,000 lbs. The rope had been lying in the open air and was covered with rust in some places.

Rope No. 2 was 0·95 inch in diameter, and was composed of six strands, each strand had a wire core 0·07 inch diameter, around which were six wires 0·06 inch diameter, covered again with eleven wires 0·07 inch diameter. The area of the rope, not including the six wire cores, was 0·3 square inch, and the guaranteed breaking weight 48,000 lbs., but which, in testing, reached 58,600 lbs.

The cast steel flat rope was 2·36 inches wide and 0·5 inch thick, and was composed of four round ropes sewn together; each rope had six wires 0·06 inch diameter, and a hemp core 0·078 inch diameter. The area of the rope was 0·369 square inches, and its guaranteed breaking weight was 55,000 lbs., reaching to 66,000 lbs. on being tested. This rope like No. 1, had been in the open air and was covered with rust in some places.

These ropes, with the different sockets, underwent 68 experiments with the following results:—

The breaking weight of the rope is a little less than that of the total of the wires composing it, due, no doubt, to the unequal tension of the wires in the rope, arising from the irregular thickness and temper of the wires, which offer an unequal resistance when being twisted in the manufacture of the rope.

The tension of the wires is also influenced by the fastening of the sockets to the ropes. In most of the trials the single wires on strands broke one after the other when they all broke together a higher breaking weight was registered.

The sockets gave results as follows:—

No. 1, or Baumann's patent, gave the highest and most uniform results. No. 2 gave the next best results; but the wires, from the rough edges of the wedges, were damaged. This is of importance, because a rope, unlike a single wire, does not form a whole, and when the outer part is held tight, the inner will move a little, causing a greater tension on the outer wires, and which, if damaged, will considerably weaken the rope.

Nos. 7, 8, and 9 gave fair results. Their fault is that the clamps cannot be made sufficiently tight to prevent the rope from slipping, so that the bolts had to be continually tightened, causing their threads to strip in two instances, and would, for this reason, not be safe for winding ropes.

Nos. 4, 5, and 6 proved quite useless; the ropes could never be held long enough to get the breaking strain, as they could not be held by the sockets. The reason seems to be, that when wires are unravelled in these sockets and are turned back, their tension is unequal, and the wires are drawn through the rings encircling them in spite of all conical rings and wedges.

The usual method adopted in England of bending the wires back over a ring and fastening the long shaped socket with pins driven through the rope and riveted was not tried. C. Z. B.

WINDING ROPES.

Ueber Schacht-Förderseile und Seilkosten. Von Herrn Wenderoth, *Zeitschrift für das Berg-, Hütten- und Salinen-wesen, Vol. XXX., pp.* 77–80.

The Official Report of the German Government upon the safety of ropes used for winding in the Dortmund district from the year 1872 has been published, and has been followed by a similar Report on the fiscal mines of Saarbrücken for the four years 1877–1880.

The reports give details of experiments and observations made upon the following number of ropes:—

	Dortmund.	Fiscal Mines of Saarbrücken.
Flat ropes of cast steel ...	87 ...	27
Do. iron	18 ...	20
Do. aloe fibres ...	19 ...	6
Round ropes of cast steel ...	388 ...	42
Do. iron	210 ...	191
Total	722 ...	286

The following Table shows the cost of the ropes—calculated by multiplying the whole length of the ropes with the average weight per metre and with the price per kilo-

gramme in marks (shillings)—the work done by the ropes given in million kilogramme metres—and lastly, the cost of the ropes per million foot pounds, given in the original per ton metre (1,000 kilogrammes lifted 1 metre high):—

Description of Rope.	Dortmund District.			Saarbrücken District.		
	Cost of the Ropes in Marks = Shillings.	Work done by the Ropes in Million Kilogrammes Metres = 1,000 Tons nearly (984 Tons) per Metre.	Cost of Ropes per Million Foot Pounds in Pence.	Cost of the Ropes in Marks = Shillings.	Work done by the Ropes in Million Kilogrammes Metres = 1,000 Tons nearly (984 Tons) per Metre.	Cost of Ropes per Million Foot Pounds in Pence.
Flat Ropes, Cast Steel ... 1877	53,280·61	361,043	0·243	4,018·00	18,928	0·350
1878	63,250·45	475,345	·220	2,123·80	10,464	·333
1879	46,746·64	423,396	·182	9,973·25	52,765	·312
1880	41,131·30	522,448	·130	8,849·80	38,286	·381
	204,409·00	1,782,232	·190	24,964·85	120,443	·342
Flat Ropes, Iron ... 1877	15,579·75	127,279	0·202	7,211·25	59,723	0·199
1878	3,147·30	13,258	·391	2,884·50	24,614	·193
1879	3,147·30	16,585	·313	2,884·50	16,226	·293
1880	2,340·30	14,002	·276	3,344·14	31,920	·173
	24,214·65	171,124	·233	16,324·39	132,483	·203
Flat Ropes, Aloe ... 1877	9,836·40	165,028	0·098	2,770·56	3,713·5	1·231
1878	18,677·28	178,773	·172	1,762·48	26,634·1	·109
1879	8,257·02	388,211	·051	2,958·25	9,080·0	·522
1880	26,486·98	605,238	·072	.....	.....	.....
	63,257·68	1,337,250	·092	7,491·29	39,427·6	·313
Round Ropes, Cast Steel ... 1877	117,783·51	1,551,781	0·125	24,099·12	275,669	0·144
1878	111,855·47	2,173,276	·085	4,050·00	69,264	·096
1879	123,367·57	2,051,150	·099	12,041·34	183,234	·108
1880	169,440,87	3,445,196	·081	14,396·96	158,568	·150
	522,447·42	9,221,403	·094	54,587·42	686,735	·131
Round Ropes, Iron 1877	45,083·62	577,973	0·129	47,454·80	872,366	0·090
1878	40,174·60	852,514	·078	25,652·49	534,454	·080
1879	29,076·78	626,155	·076	25,579·33	571,739	·074
1880	20,863·02	576,173	·027	31,139·27	669,378	·077
	134,197·92	2,632,815	·084	129,825·89	2,647,937	·081

On comparing the costs it will be seen that they stand higher in Saarbrücken than in Dortmund. The conclusion to be drawn from this is, not that ropes of an inferior quality are used in the former district, nor that the ropes are not so well taken care of, but that, as the ropes are used for drawing men and material in the Saarbrücken mines, great care and precaution is taken that the ropes are renewed as soon as any defect in them has been noticed, in order that perfect safety may result.

In many cases the ropes are taken off after having been used for one year, and in others after the rope has done a certain amount of work, even should they have shown no signs of giving way.

By this procedure, economy is not sacrificed in such a degree as the figures might lead one to suppose; it must be taken into account that the ropes, after having been in use for winding, are used for other purposes, such as for balancing in the shaft (Koepe's system), and on inclines underground.

The Table showing sudden breakages of ropes may, at first sight, appear to favour the Saarbrücken mines, but it will be seen that the percentage of sudden breakages in the number of ropes used, places the Saarbrücken district in a most unfavourable position.

The number of ropes taken off after use in Saarbrücken amount to one-third of the number taken off in Dortmund.

The sudden breakages amounted to in the:—

		Dortmund District. Per Cent.		Saarbrücken District. Per Cent.
In the year	1877	... 8·98	...	7·96
Do.	1878	... 9·40	...	1·80
Do.	1879	... 5·23	...	6·89
Do.	1880	... 4·70	...	3·13

It must be noticed here that no accidents to life have taken place through the rope breaking in the Saarbrücken fiscal mines during the years above enumerated.

The following Table shows the work done and the length of time the ropes were in use in the two districts. From this it will be seen that the number of days a rope was used on an average is not much higher in the Dortmund than in the Saarbrücken district, while on the other hand the work done by a rope on an average is much higher in the former than in the latter, showing that quick winding in the deep mines of Saarbrücken must have a deleterious effect upon the ropes:—

Year.	Dortmund.		Saarbrücken.	
	Average Work done per Rope in Million Kilogrammes.	Average Life per Rope (for winding) in Days.	Average Work done per Rope in Million Kilogrammes.	Average Life per Rope (for winding) in Days.
1877	23,787	535	10,888	444
	26,956	554	12,099	429
	28,971	539	14,363	538
	36,879	577	14,034	535

Taking the construction of the ropes into account, the flat ropes are the most expensive, in spite of their value as counterbalancing agents.

In Germany flat ropes are not used to any great extent, but principally for sinking purposes and when distance is short between the winding drum and the shaft.

With regard to the material of the ropes, flat cast steel ropes give the worst economic results, and although they are lighter than those of iron, are not to be recommended. The cost of aloe ropes is second when compared with others in the Saarbrücken district, and fourth in the Dortmund district, that is as the cheapest flat rope; they are even cheaper than round ropes of iron. Still, in both districts, as said before, they are only exceptionally in use, while in France and Belgium they are to be found nearly at every colliery. The cost of aloe ropes, even if in their construction great care and good materials be used, would not be so high as to prevent their being again generally used in Germany.

According to very accurately made rope statistics at the coal-mine at Kleinrosseln, in Lothringen, one of the largest private collieries in the Saarbrücken district, and managed by Belgian engineers, where aloe ropes are only in use, the cost of 9 ropes used in 1880 was:—

Cost	£1,408
Work done	282,874 million kilogrammes.
Cost per million foot pounds ...	0·164 pence.

The average life per rope amounted to 770 days.

It should be here mentioned how great an influence careful treatment and management has on the cost of using ropes. Above all things the spare rope kept at the collieries should be kept protected from rust. With steel ropes the freedom from rust is especially to be sought after; if they be not sufficiently protected they will not last, even if the best and the most suitable material is used in their manufacture. Often is the spare rope seen at collieries lying in the open protected only by a small wooden roof, exposed to the rain and snow. Penetrated with the damp, the ropes are often covered with rust before they have been placed for use. To preserve the ropes it is absolutely necessary that they should be kept in places where the damp cannot penetrate. The same should not be too warm or have leaky steam pipes traversing them.

It is further requisite that the ropes should be often well greased. How often this should take place depends upon the wetness of the drawing shaft; under certain circumstances about every week or fortnight. There is no difficulty in greasing them; lately machines have been constructed for the purpose, which lessen the work and bring about a better result. The grease should be rich in fat and free from acid. It should also be seen that the grease does not turn hard, for then in the deep cavities between the wires, rust can form under the grease, so that a rope may look well greased when at the same time its wires are being eaten through with rust. C. Z. B.

THE COST OF MACHINE-DRILLING COMPARED WITH HAND-DRILLING.

Der Maschinelle Bohrbetrieb auf den Gruben der Abtheilung Ramsbeck der Actien-Gesellschaft für Bergbau, Blei- und Zinkfabrikation zu Stolberg und in Westfalen. Von Herrn C. Haber, *Zeitschrift für das Berg-, Hütten- und Salinen-wesen, Vol. XXX., pp.* 43-65.

At the Ramsbeck Lead and Zinc Mines machine drills have lately been used with success for two years, and the work done has been carefully compared with that of hand-drilling, proving superior both in economy and speed.

The strata consists of hard schists and greywacke, through which veins bearing lead and zinc in the shape of sulphurets run with a gangue of quartz. The greywacke is exceptionably hard, and the progress of driving in it by hand is tedious and slow.

The cost of hand-driving for level roads 1½ yards wide and 2 yards high is as follows:—

In schist	£3 10 0 a yard.
In greywacke	5 1 6 „

For double tramway roads the price was £4 18s. and £6 5s. respectively. These prices include explosives, repairing of drills, lights, and stowing. The speed of driving the single tramway roads, with two men in eight-hour shifts and three shifts in twenty-four hours, was in schist 10 feet per month, and in greywacke 13 feet. In double tramway roads the average speed was 9 feet 10 inches per month.

The explosive used in machine drilling was dynamite. Gunpowder was not strong enough with deep holes, while gun-cotton and dynamite-gelatine were too expensive and not altogether satisfactory.

The machine drills used were of the well-known Schram type, with percussion borers; they recommended themselves after some trials with others.

The position of the holes to do the most work had to be at as great an angle to the face of the level as possible, and therefore a short drill, occupying little space and easily placed in any position, was found to be the best. Hand-drilling had to be as closely imitated as possible—that is, the holes had to be bored so as to get the least amount of resistance with a long hole.

The air-compressing machinery to supply air to the machines was of the ordinary type, and maintained a pressure of four atmospheres.

The following was the result of working with one Schram drill in driving a level winning for the whole year 1879:—

Distance driven in twelve months	106¾ yards.
Average breadth	10 feet.
Number of working days of three eight-hour shifts ...	291
Average distance driven per day	1 ft. 1·28 ins.
Do. per shift	4·41 inches.
Number of holes drilled	5,985
Total depth of the same	3,907¼ yards.
Average depth of holes per day worked	13·42 „
Do. per hole	1·96 feet.
Do. per yard driven	36·6 yards.

	£	s.	d.
Wages per yard driven	4	3	8
Total amount of wages paid	446	15	11
Cost of fuel	54	14	0
Repairs to machines	62	3	3
Loss of steel	7	16	7
Enginemen's wages	14	12	8
Stores—drilling machines	13	6	4
Do. air compressor	4	19	10
Replacement of capital and interest	39	0	0
Total cost	£643	8	7

Cost per yard	£6 5s.
Total number of single-men shifts	1,773
Men's wages, after deducting cost of lights, explosives, tool repairs (borne by them)—net earnings	£244 3s. 9d.
Average wage per man per shift	2s. 9d.
Explosives used—dynamite	16½ cwts.
Do. gun-cotton	2½ „
Do. fuse	453 pieces.
Number of detonating caps	5,533
Cost of explosives	£161 17s. 2d.
Do. per yard driven	£1 10s. 4d.

COMPARISON OF HAND AND MACHINE-DRIVING.

Cost of doing the same work by hand	£810 3s.
Saving, taking economy and speed into account	304 per cent.
Saving in money by using machine drills	£116 14s. 5d.
Do. per yard driven	£1 11s. 2¾d.
Do. per cent.	20·6

Interest on capital and amortizement was placed at 13 per cent. on the capital, which was £900 for three machine drills, including service of pipes and air-compressing machinery. Two drills were used in sinking.

The drift varied from 7 feet 3 inches in width to 9 feet 6 inches; the former is dead and the latter is ore-bearing ground.

The following gives the different items in percentages:—

	Per Cent.	Per Cent.
Wages	67·98	
Engineman and stoker (air-compressor and boilers) ...	2·47	
		70·45
Repairs to machine		10·49
Fuel	9·24	
Loss in steel	1·32	
Stores for machine	1·08	
Do. air-compressor	0·84	
		12·48
Amortization and interest		6·58
		100·00

The loss of steel in machine-drilling is nearly the same as that in hand-drilling, accounted for from the fact that by hand-drilling the head as well as the edge of the drill wears.

Each machine requires two men, and these do all the work necessary except laying the rails.

The air pipes were of wrought iron, but are now being replaced by cast iron ones on the score of economy. The holes are bored wet, and therefore water pipes are also used to conduct water with as great a head as possible to the borehole.

A great advantage in using machine drills worked by compressed air is the gain in ventilation. The health of the workman suffers when drilling by hand through the continual vibration caused by striking the drill; also the cramped position, often requisite while drilling, is injurious.

The saving effected in sinking and level driving for one year amounted to £920, or more than the cost of the whole machine drilling plant. C. Z. B.

IMPROVEMENTS IN MINING MACHINERY IN PRUSSIA DURING THE YEAR 1880.

Versuche und Verbesserungen bei dem Bergwerksbetriebe in Preussen während des Jahres, 1880. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen. Vol. XXIX., pp.* 238–276. *Folding Plates*, 15–21.

Underground Stone Hand Borers.

Machines for boring air holes used as stentons in winning places have come very much into use. Four are recommended—those of Munschied, Gildemeister and Kamp, Wegge and Pelser, and Hussmann. They are rotary drills, having jagged teeth cutting edges in circumference of drill.

The Husmann machine is a drill inside a drill, the centre being a twisted-shaped tool, which breaks up the core made by the outer drill. Four men are necessary to work this drill in one shift of eight hours, and in that time 34 to 46 feet can be bored, the drills having a diameter of 12 inches for the large one and 1½ inch for the centre one.

Machine Borers.

The only machine which has attracted attention during the year is Brandt's Patent Hydraulic Stone Borer. This drill is circular and makes a core, and is driven by two hydraulic engines, the pressure of water being derived from the pumping column in the shaft. The exhaust water and also the full pressure of the water can be made to pass through the hollow drill, to wash the hole; and the full pressure of water, by means of a piston attached to the drill, forces the drill against the rock whilst rotating. It, therefore, does not powder the stone like the percussion borers, nor grind it like the diamond borers, but it breaks the stone, the drill having peculiar cutting edges. It uses about one-half cubic foot of water per minute.

Explosives.

Compressed prismatic gunpowder—"Cartouchenpowder"—is made up in small cartridges about 1½ inch long and ¾ inch diameter. Its cost, compared with ordinary gunpowder, is as 1 to 1·43, but gives a better result as 1·71 is to 1.

Fairholme and Co.'s woodpowder has with several trials proved itself to be unsatisfactory. It consists of KNO_3 (impure), 61·4 per cent., sawdust 26·5 per cent., and sulphur 12·1 per cent.

Compressed gun-cotton has given better results than expected, but has to be kept exceedingly dry to get good results.

Nobel's explosive gelatine, or gelatine dynamite, has been tried, and, compared with dynamite, gives good results. Its cost is high, being nearly twice that of dynamite. The unaccountable explosions occurring at two collieries in Germany, in magazines stored with gelatine dynamite, have cautioned mining engineers against its use.

Iron Shaft Timber.

At the Shamrock No. 2 Pit (Westphalia) the guides and buntons are of wrought iron. The buntons are of angle iron, and are fastened to wrought iron rings or cribs fixed in the pit. The guides are of channel iron, fastened by bolts and nuts to the buntons. The guides are 10 yards long, and each length is fastened to three buntons. The guides, buntons, and rings cost £1 16s. per yard complete, with labour and materials. In fourteen days 220 yards of this work was finished.

Pump worked by a Water Column used as a Transmitter of Power.

At the Uni Mine, Unterste Martinshart, a pump 106 yards below the main pump rods, and 90 yards from the shaft, is worked by means of a water column, which derives motion from a plunger worked by the main pump rods. By this means a piston is moved backwards and forwards, to which is attached a lifting and forcing pump at the other end of the column. An air vessel is attached to the column, and the whole has been at work for several months, working well in all respects.

Bleichert's Wire-rope Railway.

At several collieries and iron mines in Germany Bleichert's rope railways are used, which consist in suspending one or two ropes, or wrought iron rods, from pole to pole, over roads, rivers, etc., at any distance above the surface, on which trams or carriages are hung on wheels, and which are moved backwards and forwards by an endless rope supported and fastened to the carriages below the other ropes.

It is only used for short distances, to take slag or dirt to refuse heaps, or small quantities of mineral, and their great advantage is that they can cross uneven ground at little trouble and expense. The speed reaches sometimes four miles an hour, transporting per day of ten hours a quantity of 100 to 200 tons of mineral, at a cost per ton per mile of about sixpence.

Ventilators.

A Pelzer ventilator has been erected at the Bruchstrasse Colliery. It is a centrifugal fan, with screw-like vanes, having a diameter of 8¼ feet. With a speed of 224 revolutions per minute, the inlet drift having an area of 24½ square feet, the quantity of air exhausted per minute amounted to 27,318 cubic feet at a speed of 1,115 feet per minute, the water-gauge standing at $1\frac{1}{10}$ inch.

Air-Compressors.

At the lead-mine, Friedrichssegen, a Sommeiller's air-compressor has been replaced by one of Dubois and François'. The peculiarity of this air-compressor is that little space is wasted between the piston and the exit valves, and that water is partially used in driving the air before the piston. The water is forced in a small quantity at the end of each stroke in the form of spray. The inlet valves are in an inclined position, gaining thereby an increased area. The following is the result of experiments made:—

Speed of piston per second in feet	2	2½	3¼	4	4½
Number of strokes per minute	15	20	25	30	35
Cubic feet of air compressed to give one cubic foot of air at 5¼ atmospheres	5·32	5·43	5·55	5·81	6·41
Amount of air drawn into compressor, at the temperature and pressure of the atmosphere, taking the volume of compressed air as unity	0·94	0·92	0·90	0·86	0·78

The steam engine working the compressor has one steam cylinder, 1 foot 7·7 inches diameter, with a 3 feet 11·3 inches stroke. The air-compressing cylinder is driven by the piston rod of the steam cylinder, and is 1 foot 5·7 inches diameter. 120 cubic feet of air are compressed per minute to a pressure of 5 atmospheres.

C. Z. B.

STEEL RAIL GUIDES.

Note sur les guidonnages métalliques établis aux fosses d'Havré. Par Ch. Demanet, *Rev. Univ. des Mines, Vol. VII.*, 1880, *pp.* 549–555. *One folding Plate, No.* 22.

The arrangement consists of four guides (2 for each cage) fastened to two buntons.

The rails are vignoles made of steel, and weighing 29 kils. per metre (58 lbs. per yd.) They are 8·5 metres long (9 yds.), fished and bolted to oak buntons 2·10 × 0·15 × 0·20 metres, and set 1·5 metres apart.

In the walling, the buntons are set into cast iron sockets.

In the tubbing, iron circles of U section rest upon the ribs of the tubbing, and these circles carry transverse girders to which the rails are attached.

Two millimetres (0·078 in.) are left open between the ends of the rails for expansion, and the bolt holes in the rails and fish plates are made oval in the usual way.

Rail guides are generally (in this case the rails were exceptionally low) more expensive than wood; but M. Demanet thinks that the additional cost is more than compensated for by their superior rigidity and durability.

Cost where Shaft Tubbed.

	Francs Per Metre.	Per Fm. £ s. d.
a.—Circles:—		
Each circle weighed, including bolts, 182 kilos., and cost 30 francs per 100 kilos. (400 lbs. at £12 4s. 4d. per ton). They were placed every 2 metres (1·09 fms.) = 54·60 fr. (£2 3s. 8·16d.)		
To each circle there are two oak sleepers (1·25 × 0·08 × 0·16) × 2 metres = 0·032 cub. metre (1·128 cub. ft.) costing 4·8 fr. (3s. 10·08d.)		

	Francs per Metre.	Per Fm. £	s.	d.
To each circle there are 8 bolts and washers, 2·16 francs (1s. 8·71d.)				
Erecting, 1·8 fr. (1s. 5·28d.)				
Total for each circle complete, and placed in pit per metre and per fathom	31·68	2	6	4
b.—Rails :—				
There are 4 metres of rail guides for each metre of shaft. The 4 metres weigh 116 kilos. at 14 fr. per 100 kilos. (256 lbs. at £5 14s. per ton) = 16·24 fr. (£1 3s. 9d. per fm.) ...	16·24	1	3	9
Putting guides into shaft 1·95 fr. per metre (2s. 10·3d. per fathom)	1·95		2	10·3
c.—Fish plates :—				
·6 × ·085 × ·085. 4 of them per 8·5 metres, weighing 7·5 kilos. and costing 9·28 fr.	1·10		1	7·3
Total per metre and per fathom	50·97	3	14	6·6

COST WHERE SHAFT WALLED.

	Francs per Metre.	Per Fm. £	s.	d.
a.—Buntons :—				
The buntons are placed 1·5 metres (4 feet 10½ inches) apart, they are of oak, 2·10 × 0·15 × 0·20 (6 feet 10½ inches × 6 × 8 inches). Two buntons cost 18·9 fr. Each pair requires 8 bolts and washers = 2·64 fr. Putting up in shaft = 2·50 fr. Total for each pair of buntons, 24·04 fr., which is per metre and per fathom	16	1	3	3
b.—Rails :— } *c.—Fish plates :—* } as above	19·29	1	8	3
Total per metre and per fathom	35·29	2	11	6

If the guides had been made of oak 0·15 × 0·18, and costing 180 fr. the metre cube (5·89 × 7·07 inches at 4s. per cub. ft.), the cost per metre would have been 19·44 fr. instead of 16·24 (£1 8s. 4d. per fm. instead of £1 3s. 9d.), without taking into account the cost of erection, more expensive in the case of wooden than of iron or steel guides. J. H. M.

AIR-COMPRESSORS—LOSS OF PRESSURE FROM FRICTION OF THE AIR IN THE PIPES.

Expériences faites au Tunnel du Saint-Gothard sur l'Ecoulement de l'air comprimé en longues conduites métalliques pour la transmission de forces motrices. Par E. STOCKALPER, *Ingénieur-Chef de Service. Rev. Univ. des Mines, Vol. VII., Sér.* 2, 1880, *pp.* 257-281. *Plates,* 10-12.

The co-efficients of friction usually given for the flow of air through pipes being at variance with the practical experience of M. Stockalper, he has made experiments at the Saint-Gothard Tunnel, and finds the loss of pressure to be very much less than that given by the ordinary formulæ.

His experiments were made with two pipes. The first, 5,000 yards long and 7·8 inches in diameter (4,600 × 0·20 metres), made of cast iron, fastened together with bolts and caoutchouc rings. The second, 570 yards long and 5·8 inches diameter (522 × 0·15 metres) of wrought iron and similarly joined.

The quantity of air passing per second was calculated from the strokes of the compressor.

The pressures were taken by Bourdon gauges, and the temperatures of the air in the pipe by thermometers, so arranged that they could be read without removing the bulb from the interior of the pipe.

M. Stockalper comes to the conclusion that to calculate the loss of pressure it is sufficient to treat the question as if the pipe contained water flowing at the same velocity as the air, and to reduce the loss of pressure found from water in the ratio of the density of the compressed air to that of water.

Thus let—

J = Loss of pressure in atmospheres for a pipe one metre long.

$\acute{a} = \frac{a}{1000}$.

a = See Darcy's table.

Q = Volume of air passing per second in cubic metres.

δ = Weight of one cubic metre of the flowing air in kilogrammes.

$J = \acute{a}, Q^2 \delta$

In English units when—

J = Loss of pressure per yard of pipe.

$\acute{a} = \frac{a}{1000}$.

a = See Darcy's table.

Q = Cubic feet per second.

δ = Weight of one cubic foot in ounces.

$J = \left\{ \acute{a}. \left(\frac{Q}{35{\cdot}316}\right)^2 \times \delta \right\} 0{\cdot}914$, which approximately $= \acute{a}, Q^2 \delta\, 0{\cdot}000733$.

Total loss $= J\,l = (\acute{a}, Q^2 \delta)\, 0{\cdot}000733\, l$ where l = length of pipe in yards.

D in Darcy's table = the diameter of the pipe in inches divided by 39·37.

DARCY'S TABLE FOR CAST OR WROUGHT IRON PIPES, NEW.

Diameter in Metres. D.	a.	Diameter in Metres. D.	a.	Diameter in Metres. D.	a.
0·01	58,395,000	0·18	9·918	0·39	0·194055
0·02	1,169,250	0·19	7·5295	0·40	0·17067
0·027	222,800	0·20	5·7855	0·41	0·15056
0·03	125,155	0·21	4·50925	0·42	0·133225
0·04	26,280·5	0·216	3·90305	0·43	0·118435
0·05	7,937	0·22	3·5546	0·44	0·10538
0·054	5,267·5	0·23	2·8361	0·45	0·094005
0·06	3,010·45	0·24	2·2805	0·46	0·08422
0·07	1,333·05	0·25	1·8526	0·47	0·075495
0·08	660·95	0·26	1·51725	0·48	0·067825
0·081	619·3	0·27	1·2518	0·49	0·06118
0·09	356·905	0·28	1·0418	0·50	0·055195
0·10	206·21	0·29	0·8710	0·55	0·034114
0·108	138·135	0·30	0·73385	0·60	0·0220155
0·11	125·625	0·31	0·6206	0·65	0·0146985
0·12	80·005	0·32	0·52855	0·70	0·010128
0·13	52·92	0·325	0·488235	0·75	0·0071595
0·135	43·529	0·33	0·45235	0·80	0·005175
0·14	36·111	0·34	0·388915	0·85	0·00381445
0·15	25·3195	0·35	0·33521	0·90	0·00286075
0·16	18·1505	0·36	0·29063	0·95	0·00173075
0·162	17·0285	0·37	0·252955	1·00	0·00168275
0·17	13·313	0·38	0·221375		

Experiments of 17th December, 1878.

Comparison between the Results observed and those calculated by different Formulæ.

	Diameter in metres. D	Length in metres. l	Volume passing in M³ at 0° and the barometric pressure of Paris. V_0	Mean pressure in atmos. $p = \frac{p_1 + p_2}{2}$	Mean temperature in pipe. t_0	Weight of a cub. met. of air at the mean density δ in kilogrammes.	Average Volume passing at the mean density in cubic metres. Q	Average velocity in metres. U	Loss of Pressure in Atmospheres (of 10,334 Kilogr.), Calculated from Formulæ.					
									Observed.	$J = d, Q^2, \delta$	Girard d'Aubuisson Pecqueur.	Morin.	Arson.	Weisbach.
	M.	M.	M³.	Atm.		Kil.	M³.	M.						
No. 1	0·20	4,600	0·936	5·42	21°	6·500	0·185	5·89	0·36	0·57	0·61	0·64	0·90	1·25
	0·15	522	0·936	5·12	26·5	6·030	0·200	11·32	0·24	0·30	0·31	0·34	0·48	0·46
No. 2	0·20	4,600	0·623	4·285	21	5·140	0·156	4·968	0·22	0·32	0·345	0·30	0·52	0·76
	0·15	522	0·623	4·095	26·5	4·820	0·166	9·394	0·07*	0·17	0·175	0·15	0·27	0·29
No. 3	0·20	4,600	0·520	3·745	21	4·490	0·149	4·747	0·19	0·25	0·27	0·29	0·41	0·63
	0·15	522	0·520	3·597	26·5	4·230	0·158	8·942	0·105	0·135	0·14	0·15	0 22	0·23

* Error of observation probably.

It will be observed that M. Stockalper's formula, though agreeing more nearly with the results of practical experiments than those of the other observers quoted, gives a loss of head larger than is found to be really the case.

J. H. M.

SEPARATE VENTILATION AND ITS COST.

Über Separatventilation und ihre Kosten. Von B. R. Förster, *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1882, *Figs.* 1–5, *Plate I., pp.* 1–17.

In several mines in Germany separate ventilation has been adopted. A system of pipes is necessary to convey the air from the surface to the point where it is required underground at a sufficient pressure to overcome friction, either to issue into the working place or to transmit power to a ventilating machine. The following formula will enable the loss of pressure through friction to be calculated. It has been found to agree with experiments made by Stockalper in the St. Gothard Tunnel.

$$Z = \frac{76}{10^{10}} \cdot \frac{l}{d} \cdot \delta \left(5 + \frac{1}{d}\right) \cdot u^2 \cdot \times 10{,}334$$

Where Z = Water-gauge in millimetres of loss of pressure of air from friction through moving in pipes.

l = The length of pipes } in metres.
d = The dia. of pipes }

u = The velocity of the air in metres per second.

δ = Weight of 1 cubic metre of compressed air at a temperature of 20 degrees C. (taking into account heat of the mine) in kilogrammes.

Table I., page 33, shows the loss of pressure of air on flowing through pipes a length of 1,000 metres, at different initial pressures and with different sized tubes.

At the fiscal colliery Zankeroda in Saxony, extensive trials lasting over three years have enabled the cost of such ventilation to be got at.

The cost of 1 cubic metre of air reduced from a pressure of 3 atmospheres additional pressure, to 0 atmosphere pressure has been found to be 4·2d.

a.—Then by simply allowing the compressed air to flow into the workings 1 cubic metre of air cost 4·2d.

b.—By employing a Kirting's blowing apparatus, which draws external air to assist the compressed air, similar to an injector, the cost is $\frac{4{\cdot}2}{6{\cdot}64} = {\cdot}636$d.

c.—By employing a Woolf's transmitter to drive a Root's ventilator the cost has been found to equal $\frac{4{\cdot}2}{32{\cdot}7} = {\cdot}132$d. per cubic metre.

These costs are exclusive of amortization and interest on capital.

Air compressed by a centrifugal ventilator would be found to be the cheapest, but the pressure of such air would vary from 10 to 160 millimetres water-gauge, or an average of 60 millimetres. In Table I. 10 millimetres water-gauge has, however, been taken. Centrifugal ventilators, now almost universally adopted to ventilate mines, could by a mechanical contrivance be made, while ventilating a mine as usual, to compress air on the exit side to be used for separate ventilation; or separate centrifugal ventilators could be adopted to send the air into the mine. Mr. A. Brandt, engineer, for the purpose of sending compressed air through 5,000 metres of piping in the Vorarl Tunnel Works, used 3 centrifugal ventilators, one placed in front of the other. The engines indicated 200 h.p., the pressure amounting to 3·5 to 4 metres water-gauge, or nearly half an atmosphere. The following results were obtained with:—

Revolutions per Minute.		Millimetres Water-gauge.		Giving Cubic Metres of Air per Second.
900	...	650	...	1·5
1,050	...	750	...	1·75
1,120	...	1,000	...	2·25
1,220	...	1,150	...	2·5
1,290	...	1,225	...	2·55
1,320	...	1,300	...	2·88

By simply employing a centrifugal ventilator at a colliery to compress air at the same time while discharging, the cost is small, as it has been ascertained at the Zankeroda colliery to equal ·00252d. per cubic metre. This is small, but the pressure obtained in such cases is scarcely sufficient, unless by a speed of only 2 metres per second, to overcome the friction in the pipes.

By Brandt's 3 centrifugal ventilator system the cost was found to be, at a pressure of one-fourth atmospheres, ·576d. per cubic metre. With air compressing machines at the Marien colliery this cost was ·744d. per cubic metre.

Power may be transmitted underground by means of electricity created on the surface and taken underground either in copper wires or by old ropes. This has been done at Blanzy, and Messrs. Siemens' and Halske, the celebrated electricians, are preparing one for the colliery Zankeroda, which costs, with generator, engines, etc., £250, and which with 4½ to 5 h.p., will transmit 2 to 2½ h.p. (50 per cent. duty), to a separate ventilator which it is calculated will deliver 50 to 75 cubic metres of air per minute, at a cost of ·096d. per cubic metre.

100 cubic metres of air per minute would suffice for 40 men a shift, and taking the gain of health and increased work done by receiving a plentiful supply of fresh air, the author ventures to say that the first cost of separate ventilation could be covered in a year.

TABLE I.

Showing Loss of Pressure of Compressed Air through Friction in Pipes 1,000 Metres Long.

N.B.—This loss is reduced in the same proportion as a reduction in the length of the Pipes.

1.—By 3 Atmospheres Pressure of the Air (31,002 Millimetres Water-gauge).

Quantity in Cubic Metres of Air per Min. reduced to 0 Atmosphere Pressure, and Dia. of Pipe in Millimetres.	Loss of Pressure of the Air in the Pipes in Millimetres of Water-gauge when moving at the following Velocities in Metres per Second.						
	1	2	4	6	10	20	
5	26	180	1,295	4,154	18,243	137,704	Friction greater than initial pressure; therefore latter is not sufficient to send air through 1,000 metres of pipes.
Dia. of Pipes =	163	115	81	66	51	36	
10	15	103	721	2,259	9,685	72,946	
Dia. of Pipes =	230	163	115	94	73	51	
25	8	50	349	1,069	4,504	31,721	
Dia. of Pipes =	364	258	182	149	115	82	
50	5	32	209	648	2,581	18,017	
Dia. of Pipes =	515	364	258	210	163	115	
100	3	18	128	380	1,537	10,326	
Dia. of Pipes =	729	515	364	297	230	163	

2.—By 0·1 Atmospheres Pressure of the Air (1,033 Millimetres Water-gauge).

5	3	17	116	358	1,534	10,846	Friction greater than initial pressure; therefore latter is not sufficient to force air through 1,000 metres of pipes.
Dia. of Pipes =	321	227	160	131	101	72	
10	2	10	68	208	862	6,096	
Dia. of Pipes =	454	321	227	186	144	101	
25	1	5	35	106	424	2,877	
Dia. of Pipes =	718	508	359	293	227	161	
50	1	3	21	66	261	1,713	
Dia. of Pipes =	1,010	718	508	415	321	227	
100	0	2	13	42	164	1,046	
Dia. of Pipes =	1,440	1,010	718	586	454	321	

3.—By 0·025 Atmospheres Pressure of the Air (258 Millimetres Water-gauge).

5	2	17	107	335	1,420	10,140	Friction greater than initial pressure; therefore latter is not sufficient to force air through 1,000 metres of pipes.
Dia. of Pipes =	322	227	161	131	102	72	
10	1	9	65	194	805	5,606	
Dia. of Pipes =	455	322	227	186	144	102	
25	1	5	34	99	381	2,688	
Dia. of Pipes =	719	509	360	294	227	161	
50	0	3	21	62	243	1,600	
Dia. of Pipes =	1,010	719	509	415	322	227	
100	0	2	13	39	153	969	
Dia. of Pipes =	1,440	1,010	719	585	455	322	

4.—By 0·001 Atmospheres Pressure of the Air (10 Millimetres Water-gauge).

5	2	15	102	321	1,383	9,894	Friction greater than initial pressure; therefore latter is not sufficient to force air through 1,000 metres of pipes.
Dia. of Pipes =	326	230	163	133	103	73	
10	1	9	60	182	786	5,536	
Dia. of Pipes =	464	325	230	188	145	103	
25	1	5	33	92	372	2,565	
Dia. of Pipes =	728	515	364	297	230	163	
50	0	3	21	57	233	1,488	
Dia. of Pipes =	1,030	728	515	420	326	230	
100	0	2	12	36	144	933	
Dia. of Pipes =	1,450	1,030	728	594	464	326	

C. Z. B.

FRENCH MINERAL STATISTICS FOR 1879.

Statistique de l'Industrie Minérale de la France. Production des combustibles minéraux, des fontes, des fers, des tôles et des aciers pendant l'année 1879. *Annales des Mines, Sér* 7. *Mémoires, Tome XVII., pp.* 299-304.

This paper consists of seven tables, showing the production of coal, lignite, iron, and steel in detail. Two of these are here given, viz., the production of coal and lignite for 1878 and 1879:—

I.—Production of Coal and Anthracite.

Name of Coal-field.	Where Situated.	Production, 1879.	Production, 1878.
		Tons.	Tons.
Valenciennes	Nord-Pas-de-Calais	7,251,969	6,992,122
Loire	Loire-Rhône	3,050,177	3,107,986
Alais	Ardèche-Gard	1,797,873	1,682,325
Creusot et Blanzy	Saône et Loire	938,118	1,010,955
Commentry	Allier	770,963	757,639
Aubin	Aveyron	665,770	656,455
Carmaux	Tarn	293,800	291,620
Brassac	Loire (Haute) Pay-de-Dôme ...	228,099	218,560
Graissessac	Hérault...	221,685	240,749
Décize	Nièvre	173,739	183,362
Ronchamp	Saône-(Haute)...	164,060	182,674
Ahun	Creuse	158,783	199,096
Saint-Eloy	Puy-de-Dôme	127,450	145,732
Epinac	Saône et Loire	121,411	131,074
Le Drac	Isère	95,210	93,847
Hardinghen	Pas-de-Calais	93,817	77,733
Le Maine	Mayenne-Sarthe	78,696	97,387
Basse-Loire	Loire-Inférieure—Maine et Loire	53,300	56,861
Bert	Allier	38,276	41,503
Vouvant et Chantonnay ...	Sèvres (deux) Vendée ...	36,212	49,638
Sainte Foy l'Argentière ...	Rhône	34,002	33,344
Buxière-la-Grue	Allier	33 382	33,210
Langeac	Loire (Haute)	27,823	36,206
La Chapelle-sous-Dun ...	Saône et Loire	24,973	22,923
Maurienne Tarentaise et Briançon	Alpes (Hautes)—Savoie ...	21,345	24,209
	Carried forward	16,500,933	16,367,210

I.—Production of Coal and Anthracite.—*Continued.*

Name of Coal-field.	Where Situated.	Production, 1879.	Production, 1878.
		Tons.	Tons.
	Brought forward	16,500,933	16,367,210
Le Vigan	Gard	13,170	7,696
Rodez	Aveyron	12,881	11,708
Aubenas	Ardèche	7,153	5,871
Fréjus	Var	7,106	7,670
Sincey	Côte-d'Or	6,839	7,639
Littry	Calvados	4,800	6,974
Roanne...	Loire	4,251	5,442
Communay	Isère	3,296	585
Terrasson	Corrèze—Dordogne	2,960	3,243
Bourg-Lastic	Puy-de-Dôme	2,879	2,797
Champagnac	Cantal	2,144	3,161
Bourganeuf	Creuse	1,898	2,777
Saint Pierre-la-Cour	Mayenne	1.511	3,011
Saint-Perdoux	Lot	1,358	1,184
Meymac	Corrèze	1,305	1,039
Aubignez-la-Ronce	Côte-d'Or	1,170	...
Other Coal-fields		1,200	2,643
	Total	16,576,854	16,440,650

II.—Production of Lignite.

Name of Coal-field.	Where Situated.	Production, 1879.	Production, 1878.
		Tons.	Tons.
Aix	Bouches-du-Rhône—Var ...	429,480	420,381
Manosque	Alpes (Basses)—Vaucluse ...	39,818	44,198
Bagnols	Gard	16,001	13,706
Gouhenans	Saône-(Haute)	10,914	9,179
Orange	Vaucluse	5,950	7.664
Norroy	Vosges	5,635	2,005
Milhau	Aveyron	4,057	4,547
Entrevernes	Savoie (Haute)	2,334	4,456
La Tour-du-Pin	Isère	2,110	2,021
Barjac	Gard	2,048	2,291
La Cadière	Var	1,456	1,268
Célas	Gard	1,452	1,827
Estavar	Pyrénées-Orientales	1,439	676
Méthamis	Vaucluse	1,400	1,212
Banc-Rouge	Ardèche	1,209	1,083
Other Coal-fields (6 in 1879, 8 in 1878 ... ...)	... ...	2,328	3,752
	Totals	527,631	520,266

J. H. M.

THE SAARBRÜCK COAL-FIELD.

Les Houillères et les Usines Sidérurgiques de la Saar. Extrait d'une notice sur le district industriel de la Saar. Par A. HASSLACHER; *Traduit par* M. A. DE VAUX. *Revue Univ. des Mines, Sér.* 2, *Tome VII.*, 1880, *pp.* 457–485.

A paper has already been read on this coal-field by Mr. A. R. Sawyer, and published in Vol. XXVIII. of the Transactions.

PRODUCTION AND MEN EMPLOYED.

	Tons.	Men.
1744	3.650	...
*1767	...	...
†1790	50,000	...
1813	83,350	700
‡1816	100,319	917
1825	142,962	1,038
1850	593,855	4,580
1875	4,481,834	...
1878	4,980,648	25,592

* Coke ovens erected. † France held the country from 1792 to 1814.
‡ Crown of Prussia holds the mines.

An unsuccessful attempt was made at Gerhard Colliery in 1816–1819 to use a locomotive steam-engine on a road about 2,000 yards in length laid down with rails. The engine was built at Berlin, but it could not be made to work regularly.

J. H. M.

THE MINERAL STATISTICS OF THE KINGDOM OF SAXONY FOR THE YEAR 1880.

Statistische Mittheilungen über das Bergwesen im Königreiche Sachsen, 1880. *Jahrbuch für das Berg- und Hütten-wesen im Königreiche Sachsen*, 1882, *pp.* 1–197.

	Metalliferous Mines.	Coal Mines.	Lignite Mines.
Number of mines in 1880	265	61	139
Persons employed	8,426	17,045	2,570
Total number of persons employed, 28,041, with a population depending upon the same of 65,299.			
Output in tons	45,414	3,622,352	590,118
Tons raised per man per annum	5·3	212·5	229·6
Value of production	£262,175	£1,270,369	£93,417
„ per ton at pit's mouth	£5 15s. 6d.	7s.	3s.
Deaths by accident	*22	†33	‡7
„ per 1,000 employed	2·61	1·94	2·72
Number of persons employed per death	383	516	367
		490	
Tons raised per death	2,064	109,768	84,302
		105,312	

* Of these 11 lost their lives through the breaking down of a man-engine at the Himmelfahrt Mine on Feb. 29th, 1880, 5 by shot firing, 5 by other causes underground, and 1 by feed-pump on the surface.

† Of these 3 by kirving in the coal, 1 by shot firing, 2 by fall of coal, 1 by a fall in the broken, 4 in shafts, 10 by fire-damp, 2 by machinery, 10 by other causes.

‡ Of these 1 by kirving, 1 in shaft, 1 by black damp, and 4 by other causes.

C. Z. B.

THE GREASING OF PIT TUBS WITH CLOSED AXLE BOXES.

Einrichtung zum Schmieren von Förderwagen mit geschlossenen Radbüchsen auf der Königl. Steinkohlengrube Friedrichsthal bei Saarbrücken. Von HERRN BAUMANN. *Zeitschrift des Berg-, Hutten- und Salinen-wesen, Vol. XXIX., p.* 65. *Plate V.*

The axles of the tubs run in a circular casing which forms the axle boxes, and at the same time a receptacle for grease, for the casing or tube only fits close round the axle at its ends, while the middle part is made larger in diameter, so that it can hold a supply of grease which lubricates the axles in the boxes readily.

The grease must be thin, and the thick tub grease is made thin by submitting it to pressure, which at the same time forces the grease into the grease-casing round the axle.

A small air-pump forces air into a vessel partially filled with grease. The tub to be greased is run into the kickup, and while being emptied a hose pipe attached to the bottom of the grease vessel is placed over an opening in the axle-box casing, which is closed by a screw-cap, and on opening a tap attached to the hose pipe grease is forced from the air vessel into the axle casing.

Two minutes are occupied in greasing the tubs, which will run four weeks without having to be re-greased.

At the Colliery Friedrichsthal Saarbrücken 500 tubs are greased with 3 cwts. of grease per month. The grease vessel holds 396 lbs. of grease, so that when full it lasts more than a month, and the air pumped into the vessel keeps sufficiently compressed for three weeks, falling in that time from 2 atmospheres pressure to 1·4 atmospheres.

New tubs require to be greased more frequently, and a bad quality of grease will require another atmosphere more pressure to force it into the axle boxes.

C. Z. B.

ORE DEPOSITS OF KITZBÜHEL IN TYROL.

Die Erzlagerstätten von Kitzbühel in Tirol und dem angrenzenden Theile Salzburgs. Von F. POŠEPNÝ. *Archiv für practische Geologie, Vol. I., pp.* 257-440, *with five large folding Plates.*

This is a complete monograph of this mining district, giving every detail respecting the geology and the physical and mineralogical characters of the veins. In descending order the rocks of the region are:—(8) Glacial Drift deposits, (7) the Partnach Beds (Dolomite), (6) the Muschelkalk (Middle Trias), (5) Red Brecciated Limestone, (4) The "Grödner" Sandstone, (3) "Grauwacke" Slates, (2) Dolomitic Limestone, and (1) Clay Slate. No. 8 excepted, these rocks range from the Lower Silurian to the Permian and were formerly grouped together as "Grauwacke." In the Eastern portion of the district there are three mineral zones: a Northern clay-slate zone with the Mitterberg (copper) and Larzenbach mines, in Salzburg; a middle zone characterised by limestone with the mines of Brand in Pongau, Leogang in Salzburg, and Pillersee in Tyrol; and a Southern clay-slate zone in which is situated the Bürgstein copper mine in Pongau. In the Northern portion of the district are the celebrated silver and copper mines of Röhrerbühel, in which not only metalliferous ores are worked but also rock-salt. The central portion, or that immediately surrounding Kitzbühel itself, is made up of both slates and limestones, and comprises the Schattberg and Sinnwell mines. In the Southern portion are the iron mines of Foierling and Lanner-Gebra, the copper mines of the Kelchalp, Kupferplatten, and many others.

In all the veins copper pyrites is the prevailing ore, accompanied by iron pyrites. Nickel and cobalt ores occur less frequently, galena rarely, cinnabar and native mercury as traces only. In some lodes quartz is the common vein-stuff, in others calcite, at Leogang and Röherbühel gypsum, and baryta at the Drathalp in Pillersee. In the year 1874, the production in metrical tons was:—

Copper ore	4501·511
Nickel and Cobalt ores	156·201
Lead ore	7·000
Iron ore	17668·715

Plans and sections of the chief mines accompany the memoir, as well as woodcuts of points of petrological and archæological interest. There is also a coloured geological map of the whole district. G. A. L.

THE GOLD DISTRICT OF THE TAUERN ALPS.

Die Goldbergbaue der Hohen Tauern mit besonderer Berücksichtigung des Rauriser Goldberges. By F. Posepný. *Archiv für practische Geologie, Vol. I., pp.* 1-256. *With four large folding Plates.*

The geology of the glacier-covered chain of the Upper Tauern mountains between the Salzburg district and the Tyrol and Carinthia consists chiefly of gneiss, associated with micaschists and zones of metamorphic limestone of considerable thickness, together with some masses of serpentine and hypersthene rock, and overlying sedimentary deposit of Tertiary age. The gold of the region occurs in the gneiss, in a great number of veins, the principal of which run in a N.E. and S.W. direction, a few—more especially near the Goldberg Glacier in the centre of the district—running in the opposite direction, N.W. and S.E., and crossing the more ordinary lodes almost at right angles. The auriferous areas described form a number of separate groups of parallel lodes which may be enumerated as follows: 1. A small group at Goldzeche, with the normal direction. This is the most westerly locality mentioned. 2. A small group at Seebühel. This is perhaps a southerly extension of No. 1, but the direction is here more nearly N. and S., especially at the Seeleiten mines. 3. A small normal group at Sonnblick. 4. A scattered group with the normal direction lying to the south of the glaciers, and extending between the Sandkopf and the Eckberg. 5. The Goldberg group already mentioned, in which the veins cross each other. 6. A long series running nearly N. and S., with only a slight N.E. tendency in its southern extension, from Mitterasten, by Silberpfennig, to Siglitz. 7. A thick cluster of parallel lodes, with the normal direction at Rathhausberg, comprising the most easterly gold mines of the Tauern Alps.

Gold has been worked in this region for many centuries, and much of the detailed description in this memoir is derived from the old mining plans, some of which are reproduced. A geological map and general sections of the whole region are given, as well as sections and plans on a larger scale, illustrating the occurrence of the gold in the various mine districts above enumerated.

The gold occurs in minute particles, invisible to the naked eye, filling up interstices in the quartz which is the principal vein-filling substance of the country, and also in the iron and other sulphides which accompany the quartz. The mineral and chemical constitution of the lodes; yield of gold from the year 1660; mode of working; etc., are all discussed at length. G. A. L.

MINERAL RESOURCES OF PERSIA.

Neue Angaben über die Mineralreichthümer Persiens und Notizen über d
westlich von Zendjan. *By* General A. Houtum Schindler. *Jahr*
Kais. Kön. Geologischen Reichsanstalt, Vol. XXXI., Part II., pp. 1
with a folding Map.

This paper forms, in its first section, an appendix to the larger memoir on the subject, published in 1879, by Dr. Emil Tietze (*Jahrbuch der K. K. Geol. R* Vol. XXIX., pp. 565–658), and enumerates several new localities for the foll minerals:—Alum, lead, bolus-earth, borax, iron, edible earths, fire-clay, gold, gy coal, kaolin, copper, magnesia, manganese, marble, naphtha, porphyry, quicks rock-salt, turquois, silver, and surmeh (an antimonial sulphide used as a black colou for the eyes).

The second section is a full descri of Zendjan, bet that city and the Tawileh Mountain of longitude length. The yield of gold, silver, lea by alum the position of the mines being given i

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BRAZOS COAL-FIELD, TEXA

By C. A. Ashburner. *Trans. Amer. Inst. M.E., Vol. IX., pp.*
in text.

The Brazos Coal-field is the south-westernmost extension of th Fourth, or Western bituminous coal-basin of the United States. It 6,000 square miles within the State of Texas according to A. R. Roessler, ness of the measures being 300 feet according to B. F. Shumard, but consider according to the author. According to the latter the coal-strata proper are 85 thick, and are included between an upper sandstone and conglomerate, representin the Millstone grit or Pottsville conglomerate, No. XII. of the Pennsylvania series, and a lower grey limestone, which is the equivalent of the Mountain limestone or Chester and St. Louis limestone of the Mississippi Valley. There are two principal coal-seams, the Belknap seam above, 2½ to 4 feet thick, and the Brazos seam, 4 to 6 feet thick. The coals contain much ash and sulphur, but in the absence of better fuel in this district would be valuable.

Besides the above Carboniferous coal-bearing series which occur chiefly in Young and Stephens Counties, numerous lignitic deposits of Tertiary age are said to exist in Rush, Harrison, Cass, Grayson, Bastrop, Fayette, Caldwell, and Guadalupe Counties.

G. A. L.

AURIFEROUS SLATE DEPOSITS OF THE SOUTHERN MINING REGION.

By Prof. P. H. Mell. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 399–402.

In the North Carolina, Georgia, and Alabama gold belt, the gold lies for the most part disseminated through the slate, the quartz *seams* or reefs running through the latter often containing a much smaller percentage. The auriferous slate, which is fine-grained and talcose, occurs in zones sometimes several hundred feet in width, and varying in length from a few hundred feet to several miles, and extending to an unknown depth. The author having examined many of these formations in the Southern States, and having found them to be generally thoroughly decomposed and disintegrated, suggests that they could be worked much more easily and profitably by making use of water (which abounds in those regions) as the mining power, as is done

in the case of auriferous gravels; most of the gold mining at present carried on in the country being on the crushing system necessary for quartz, but superfluous for the soft easily-pulverised beds under consideration. G. A. L.

THE SILVER SANDSTONE DISTRICT OF UTAH.

By C. M. ROLKER. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 21–33, *with four Figures in text.*

This district lies about 320 miles south of Salt Lake City, in Washington County, near the Arizona frontier. The Sandstone formation lies in a horse-shoe belt upon the flanks of the granitic and trachytic mountains, in the midst of which the chief mining camp, Silver Reef, is situated. Sandstones and shales make up the argentiferous series, the former standing out as so-called "reefs" by weathering. Their age is uncertain—Triassic according to the author, Tertiary according to Mr. Rothwell, and Permian according to Professor G. W. Maynard. Plant remains—not very well defined—are the only fossils. The ore is chiefly cerargyrite (horn-silver or chloride of silver), but below true water level it is often sulphide of silver and native silver. The ore is disseminated in the sandstone in a very variable manner, portions of one bed being ore-bearing and others barren, and the former portions frequently being faulted or nipped out in various ways within the same bed of apparently homogeneous rock. There appears to be some relation between the presence of rich ore and that of abundant plant remains. The various workings of the region are briefly described, the monthly production being 135,000 to 150,000 dollars. G. A. L.

SOME COPPER DEPOSITS OF CARROLL COUNTY, MARYLAND.

By PROF. PERSIFOR FRAZER. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 33–49, *with folding Plate and Woodcut in text.*

This is practically a report on a copper ore property in New Windsor district, belonging to Mr. A. A. Roop. The ore occurs impregnating limestone beds of Silurian age at and near their junction with the "Hydro-Micaschists" upon which they rest. The limestone beds, including the cupriferous band at their base, lie in two parallel synclinals or troughs, the saddle between which has been removed by denudation. The ore is of two kinds: 1st.—A rich band dividing the limestone from the schists, six to eighteen inches in thickness, and consisting of mixtures of copper sulphides and a red ferruginous earth. This band or bed of ore averages 23 per cent. of metallic copper, and occurs everywhere on the property in the stratigraphical position mentioned. 2nd.—Various kinds of copper carbonates — malachite and azurite (chessylite) — permeating the limestone for from five to fifteen feet from the junction with the schists. Wherever selected for analysis within this distance the limestone yielded 12 per cent. of copper.

Zinc blende, manganese oxide, and galena are occasionally associated with the copper-bearing rocks of the place.

The length of the outcrop of the copper ores across the property is about thirteen hundred feet. The length of the curve of the ore underground is about fourteen hundred feet. The minimum thickness of the copper-bearing rock is five feet. From these data and the specific gravities found, the author gives 700,030 as the number of tons (of 2,352 pounds) of copper ore on the property, the yield of metallic copper from which, on the lowest computation, would be 84,004 tons (of 2,352 pounds), or 98,789 tons (of 2,000 pounds).

New Windsor is about forty miles from Baltimore. G. A. L.

THE WHOPPER LODE, GUNNISON COUNTY, COLORADO.

By Prof. Persifor Frazer. *Trans. Amer. Inst M.E., Vol. IX., pp.* 249–258, *with two Figures in text.*

The Whopper mine is situated about eight miles N.W. of Gothic City, near the eastern limit of the Ute Indian Reservation, and between Rock Creek and Whopper Creek on the western flanks of the Elk mountains. The Whopper lode, which is the same as that on which the Teller mine is placed, is a true N.W. and S.E. fissure vein, both cheeks of which are generally of fine compact "quartzite," this being the name locally given to what is really, it seems, an orthofelsite. In one place the "country" is of a black trap-like rock. The maximum observed width of the vein was 31 inches, the minimum 19 inches. The gangue is quartz, about half of which is barren. The ore is mainly pyritiferous in character. In the quartz gangue small and large crystals and lumps of pyrite and chalcopyrite occur together with occasional particles of galena. The assay value in silver of the average samples of ore from the dump heaps was high. Two small coal-fields with workable coal of a cannel-like character are situated near the Whopper claim. G. A. L.

THE GOLD-BEARING MISPICKEL VEINS OF MARMORA, ONTARIO, CANADA.

By R. P. Rothwell. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 409-420, *with one folding Plate.*

The township of Marmora is about thirty miles north of Belleville. The district consists of low rounded hills of syenitic granite, overlain on the flanks of the hills by Silurian limestones, which lie nearly flat and are in places so fine in texture as to afford a lithographic stone of fine quality.

The gold-bearing veins run N. and S. through this belt of syenitic granite. They are true fissure veins filled with quartz, and the walls and horses are of micaceous and talcose slates, evidently the product of the chemical decomposition of the syenite, from which also the vein-quartz has segregated. Calcite and crystallized black mica also occur as part of the gangue. The ore scattered through the vein stuff, sometimes in heavy bands and sometimes in detached well-formed crystals, is mispickel (arsenical sulphide of iron). In this mispickel is found, as free gold, most of the gold for which the mines are worked, but some also occur in the quartz.

Gold was first found in the district in 1865.

On the combined properties owned by the Canada Consolidated Gold Mining Company four or five parallel veins have been proved in a belt of 500 or 600 feet in width, with a proved length (beyond the company's ground) of about three miles. The east or main vein has a width of 20 feet in many places and averages 8 to 10 feet. Some three or four thousand tons of ore have been mined upon this property, and the results of many assays are given by the author. The chief results are as follows (tons of 2,000 pounds):—

Average 108 samples, 515 tons Gatling ore, $13·37 gold to the ton (by A. Thies).
Check assays, by Prof. Richards, $14·75.
Average value, Gatling ore, east vein, $14·06 per ton.
Average samples, aggregating 63 tons, Tuttle shaft, east vein, $24·88.
Average samples, aggregating 12 tons, middle vein, $30·82.

The treatment of the gold-bearing mispickel is described briefly, but will be dealt with more fully in a future paper. G. A. L

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GEOLOGY OF THE ISTHMUS OF PANAMA CANAL.

Note sur la constitution géologique de l'Isthme de Panama au point de vue de l'exécution du Canal interocéanique. By E. BOUTAN. *Annales des Mines, Sér. 7. Mémoires, Vol. XVIII., pp.* 5-58. *Two folding Plates.*

The author is a member of the Commission sent out to report on the feasibility of the proposed Canal. The rocks through which the Canal will have to pass are as follows (in descending order):—7.—Vegetable soil, soft clays, mud, coral detritus, and alluvial matter generally. 6.—Compact clays, soft tufaceous deposits, and soft sandstones. 5.—Hard and moderately hard trachytic tuffs and grits. 4.—Limestones. 3.—Hard trachytic and doleritic conglomerates. 2.—Compact doleritic and porphyritic breccias. 1.—Compact trachy-dolerites. The report is founded on a personal examination of the region, on the details of the sections exposed along the line of railway which almost coincides with that of the Canal, and on numerous borings made specially for the projected Canal. The harder rocks, 1, 2, 3, occupy the central portion of the Isthmus, 5 occurring only as isolated masses among the softer deposits, 6 and 7, which fill up the flat land between the hard rocks and the sea, both to the W. and to the E.; the limestones, 4, are of very limited occurrence.

The Plates comprise a topographical map and a sheet of sections, showing the relative altitudes and prevalence of the various rocks above enumerated, both along the railway and the Canal routes. G. A. L.

THE FORMATION OF GOLD NUGGETS AND PLACER DEPOSITS.

By Dr. T. EGLESTON. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 633-646.

The author thinks that the general theory, which regards the formation of nuggets and placer deposits as the result of the destruction of pre-existing vein-matter, does not accord with the facts as shown in the deep placer deposits. These are, in California, invariably poor at the surface, gradually growing richer in gold towards the bed-rock; the constant presence of fossil wood and the large quantity of organic matter contained even low down in these beds are also remarkable. Gold in veins is found, generally speaking, to be less pure than placer gold in the same district. Nuggets in drift deposits are mammillated in structure, and do not bear the appearance which they would do if they had been water-worn. A number of other points of difference between most placer gold and reef gold are given, and the formation of the former is assigned by the author to chemical deposition from solution. This theory, he points out, was proposed by Selwyn when he held the post of Government Geologist in Victoria, but attracted little attention at the time. Moreover, Selwyn did not state what he conceived the cause of the solution to be. Experiments are detailed which tend to show the effect of different organic substances on salts of gold in solution. In this way solutions containing ·50 gram. of chloride of gold with cork, leather, and leaves, after being three months in a dark place, were found to be colourless, but the organic substances were pseudomorphed into gold. With petroleum a similar solution had also lost its colour, and "there were suspended in it a number of very fine and long crystals of gold distributed nearly uniformly from top to bottom." A solution in which peat had been placed "was also colourless, but the gold was precipitated in the form of very small mammillary masses, recalling perfectly the form of nuggets."

Finally, the author accounts for the greater part of the gold occurring as nuggets, etc., in the deeper portions of placer deposits by assuming that water containing gold in solution, and being unable to pass the bed-rock, is kept a sufficient time in contact with the organic mineral matter (lignites, fossil wood, or pyrites, so common in deep placers) to allow the gold to be precipitated. G. A. L.

ON THE LOWER COAL-MEASURES OF BELGIUM.

By Dr. J. C. Purves. *Bull. Acad. Roy. Belg., Sér.* 3, *Vol. II., No.* 12, 1881.

The author proposes five questions to himself which he answers more or less fully in the present paper:—

1.—Does the coarse grit (*Grès d'Andenne*) of the Lower Coal-Measures form a constant horizon in the Great Carboniferous series? This question is answered in the affirmative and many detailed sections, etc., are given, which prove that all the true Coal-Measure basins of Belgium are surrounded by the outcrop of this marked bed.

2.—What is the succession of the beds between the coarse grit and the Carboniferous Limestone?

3.—What are the palæontological characters of the beds of the Lower Coal-Measures?

4.—What were the conditions under which the beds constituting the Lower Coal-Measures were deposited?

5.—What are the foreign equivalents of the Belgian Lower Coal-Measures?

The annexed Table will give the answer to this question and at the same time show the author's views as to the preceding three questions:—

Correlation of English and Belgian Carboniferous Rocks from the Coal-Measures proper to the Carboniferous Limestone proper.

England.	Belgium.
Millstone Grit Series.	Lower Coal-Measures.
Coarse felspathic grit.	Coarse grit of Andenne.
Shales and sandstones with thin coal-seams.	Shales and sandstones with thin coal-seams.
Yoredale Beds.	
Shales, sandstones, and grits.	Shales with *mytilus*.
Dark shales with *goniatites* and *posidonomyæ*.	Shales and phthanites (cherts) with *goniatites* and *posidonomyæ*, passing below into impure limestones with brachiopods.
Impure limestone, with *goniatites*, *posidonomyæ*, and brachiopods.	
Carboniferous Limestone.	Carboniferous Limestone.

G. A. L.

RELATIONS OF THE GRAPHITE DEPOSITS OF CHESTER COUNTY, PA., TO THE GEOLOGY OF THE ROCKS CONTAINING THEM.

By Prof. Persifor Frazer. *Trans. Amer. Inst. M.E., Vol. IX., pp.* 730–733.

There are two graphitic zones here; one, the richer of the two, extending from Phœnixville past the town of Windsor, near which the most important deposit of graphite occurs, to the Brandywine, the other parallel to the first and running through Pughtown. The portion of the rock in the first zone, sufficiently permeated by graphite to pay for working, is from 12 to 15 feet from wall to wall, and is supposed—chiefly from the presence of the graphite, however—to be of Laurentian or Lower Huronian age. In the mines of the Pennsylvania Graphite Company, near Windsor, from 50 to 80 car loads of half-a-ton were sent up per day (in August, 1880), the ore, or rather impregnated rock, containing about 4 per cent. of graphite. G. A. L.

ON UNDERGROUND TEMPERATURE IN CONNEXION WITH THE SIMPLON TUNNEL IN THE ALPS.

Étude de la question de chaleur souterraine et de son influence sur les projets et systèmes d'exécution du Grand Tunnel Alpin du Simplon. By G. T. LOMMEL. *Rev. Univ. des Mines, Sér.* 2, *Vol. IX., pp.* 1–55, *three folding Plates.*

A controversial paper intended to prove the feasibility of a tunnel through the base of the Simplon. The general results of observations on underground temperature in various parts of the world are first given, and then the readings obtained in the Mont Cenis and St. Gothardt Tunnels are quoted in full and compared. The formulæ used by Dr. F. M. Stapff to foretell the probable temperatures to be met with in the St. Gothardt Tunnel are especially criticised, and are said to be untrustworthy. The author's views as to the best means of proceeding in the opening out of large tunnel works are also given. G. A. L.

ON THE INCREASE OF TEMPERATURE IN THE INTERIOR OF MOUNTAINS.

De l'accroissement des températures à l'intérieur des hautes montagnes. By Dr. F. M. STAPFF. *Rev. Univ. des Mines, Sér.* 2, *Vol. IX., pp.* 56–72.

A reply to M. Lommel's strictures (see above). The author concludes with the following indications, which may be regarded as a brief *résumé* of his as yet unpublished results:—

"It must be well understood that, until a horizontal isotherm is reached, the increase of temperature (putting aside for the moment other disturbing influences) will be sensibly modified by the particular form of the overlying ground; and that below this horizontal isotherm there will be other co-efficients of increase of temperature independent of the topographical details of the surface. At present the best observations made on the temperature of the earth have given, in round numbers, 0·03 as the mean co-efficient of increase where the surface was level and of small height above sea level.

"The observations made at the St. Gothardt Tunnel give a mean co-efficient of 0·02 for a line 1,109 to 1,155 metres high in a mountain furnished with summits attaining a height of 2,800 to 2,900 metres. It seems reasonable to conclude from these two values that for lines drawn through mountains of similar nature, between the heights of 0 to 1,150 metres, the co-efficient of increase of temperature will be somewhere between 0·03 and 0·02, say, for example, 0·024 for a line at a height of 750 metres.

"With such a co-efficient the temperature in the central portion of a tunnel at the base of the Simplon might rise to 53° C. perhaps, instead of 46·9° C." The latter degree of temperature had been formerly arrived at by Dr. Stapff by direct application of the St. Gothardt experiments. G. A. L.

POWER, EFFECT, COST, AND WAGES EARNED, BY DRIVING WITH HYDRAULIC COMPRESSED AIR AND HAND-POWER DRILLS.

Kraftbedarf, Leistungen, Kosten und Lohnverdienste bei den Ortsbetrieben mit Hydraulischen und mit Luftbohrmaschinen, sowie mit Handbohrung. Von B. R. Förster. *Jahrbuch für das Berg-und Hüttenwesen im Königreiche Sachsen*, 1882, *pp.* 18-45.

At the Beihilfe Mine, near Freiberg, a series of experiments were made in driving levels, in a vein of quartz from two to three yards thick, yielding little and only poor galena, with Brandt's hydraulic, Schram's compressed air and hand drills. The three systems were tried simultaneously in three levels, which were driven uninterruptedly, except Sundays and holidays, with six men in three eight-hour shifts per day.

The air-compressing machinery consisted of a Brandt-Sulzer, with a plunger 9·85 inches in diameter and 7·88 inches stroke, a Paschke-Kästner compressor, with a 11·82 inches plunger and 15·76 inches stroke, and a reserve small compressor, driven by a water turbine, having a 9·85 inches plunger with a 13·396 inches stroke. The air was pressed to four atmospheres and conducted in gas pipes, about 1½ inches in diameter (inside), underground to the machines, a distance of about 900 yards. At first Fröhlich's drilling machine was used, but the Schram machine was liked better by the men, and, consequently, came into use, and No. 1 size, with 2·87 inches diameter cylinder, was afterwards replaced by No. 2, with 3·23 inches cylinder. Repairs were seldom necessary; a machine working for weeks together without requiring repairs.

The water pressure necessary for the Brandt's drill was got from a head of water equal to the depth at which the machine was at work, together with a pressure derived from Brandt's water pressure accumulator; this amounted to 83·5 atmospheres, of which 26·9 was owing to the head of water.

The water service pipes were 1½ inches inside diameter, and were ·18 inch thick, with screwed ferrule joints and copper face rings, and were laid a distance of about 725 yards.

The total cost of the machine drilling plant, consisting of one Brandt's, two Schram's drills with compressors, pipes, etc., amounted to £2,500.

All the levels driven had holes driven in advance on account of expecting water, and for this purpose the air drills were found the best. The men were paid for such holes up to three metres long, 1s. 6d. per metre, and above three metres in depth, 2s. 6d. Before the machine drills were introduced the amount paid was from 5s. to 6s. per metre. Four yards was easily reached with the air drills. The Brandt's drill, on account of the great diameter of the hole, viz., 2·67 inches, was considered not quite safe to approach water with.

To arrive at the power required to drive the mechanical drills elaborate experiments were made with a friction dynamometer, in order to find: 1st.—The mechanical work necessary to crush the stone by percussion or drilling. 2nd.—The power exerted by the drill on the stone. 3rd.—The power necessary to drive the water or air through the pipes. 4th.—The power exerted by the air or water on the machine. 5th.—The power exerted by the steam engine, or other mechanical power, on the air-compressor. And 6th.—The power exerted in the steam engine. To compare the results with hand drilling, experiments were made to find the work necessary to drill a hole by hand, and allowances had to be made on account of the different sized holes drilled. By hand-drilling the holes were ·9 inch diameter, compressed air drills 1·47 inch, and by Brandt's drills 2·68 inches diameter. These sizes are in the ratio of 1 : 2·44 : 8·05, taking the diameter of the hand-drilled holes as unity; the power necessary to drive them was as 1 : 3·26 : 8·04 respectively.

The following will show the distribution of power necessary for the machine drills:—

Air compressor No. 1 (Paschke Kästner) was driven by a turbine exerting a power of 9·68 horses. The useful effect of the compressor, using no expansion, was 21·7 per cent., giving ·230 cubic metres of air per minute at a pressure of four atmospheres, equal in power to 2·10 h.p. This air entered the service pipes on the inbye side of the air reservoirs into which Nos. 2 and 3 air compressors delivered.

No. 2 air compressor (Brandt Sulzer) and No. 3 (Paschke Kästner) were both worked from a Schusamkrug turbine which, with a head of water equal to 63·3 h.p., delivered to the two air compressors and a water press 31·3 h.p., showing a useful effect of 49 per cent.

The two air compressors got together 12·4 h p., No. 2 giving a useful effect of 18·2 per cent., and No. 3 of 21·8 per cent. Both of these were never worked together, one being always held in reserve. No. 2 delivered ·247 cubic metres of air per minute at a pressure of four atmospheres (without expansion) equal to 2·26 h.p., while No. 3 delivered ·295 cubic metres of air at four atmospheres pressure (without expansion) equal to 2·7 h.p. The compressed air from Nos. 1 and 3 (No. 2 being generally in reserve) amounted to 0·295 + 0·230 = 0·525 cubic metres per minute at four atmospheres pressure, equal to 2·7 + 2·1 = 4·8 h.p. Deduct from this 0·048 cubic metres of air from loss in pipes there remains ·477 cubic metres of air per minute for the drills. The loss of pressure in the pipes amounted to ·3 atmospheres, so that the ·477 cubic metres of air delivered to the drills was pressed to 3·7 atmospheres and equal to 4·04 h.p. This air worked two Schram drills, each placed in a level, the large one of which by 300 strokes per minute required ·396 cubic metres of air per minute, which exerted a power of 3·3 h.p. without expansion, and which gave ·84 h.p. duty in drilling equal to 25 per cent. The small drill took by 300 strokes per minute ·266 cubic metres of air per minute, exerting 2·2 h.p. on the drill without expansion, and giving a useful effect of ·56 h.p., or 25 per cent. duty. Each drill worked 7 hours 14 minutes per day.

As said before, the turbine working the air compressors Nos. 2 and 3 delivered also 18·9 h.p. to a water press which exerted 13·4 h.p., giving thereby a duty of 71 per cent.; this delivered 1·73 litres per second of water at a pressure of 56·5 atmospheres equal to 13·4 h.p. of which ·3 litres per second was surplus amount and which flowed into an accumulator, the rest, 1·45 litres per second equal to 11·1 h.p., found its way into the pipes. While descending to the drills, the water increased its pressure owing to its head, 26·9 atmospheres, equal to a height of 277 metres, but owing to friction only 77·8 atmospheres pressure, or 15·3 h.p., found its way to the Brandt's drilling machine. Of this 71·5 per cent. was lost in friction and 20 per cent. in loss of water, giving a useful effect of 1·3 h.p. only, or a duty of 8·5 per cent. The machine worked daily 2 hours 22 minutes.

The reason of Brandt's drill working less time than Schram's, was that the former, owing to the large size of hole drilled, required a less number of holes and depth of same per metre of drift driven. Brandt's machine drilled 6·2 holes per metre driven with a total depth of 6·60 metres. Schram's drill, on the other hand, drilled 33·9 holes per metre driven with a total depth of 25·58 metres. By hand drilling these figures were respectively 45·7 and 22·30 in one drift, and 38·7 and 19·60 respectively in another drift.

The speed of driving by hand, taking an average of five levels, was 0·021 metres per man per shift, including boring in advance, or ·0236 without advance boring, or it took 48·9 shifts of one man each to drive one metre, of which 6·6 shifts of one man each were required for advance boring. The Schram drill advanced the drift ·132 for the large drill, and ·111 metres for the small drill, per man per shift, or 7·55 and 9·00 shifts

per man respectively, for one metre driven, including advance boring. The Brandt drill was even quicker, advancing at the rate of ·144 metres per man per shift, or 6·92 shifts per man for 1 metre driven.

The cost is given in the following Table. Under "hand drilling" the total and average of five levels driven is taken into account:—

	Hand Drilling.	Schram No. 1.	Schram No. 2.	Brandt.
Duration of experiment, weeks	179	39	8	29
Distance driven, metres	171·1	182	32	144
Dynamite and gelatine dynamite per metre driven in kilogrammes	*5·77	9·71	8·05	9·72
Wages per metre driven, including advance boring	£ s. d. 25 5 2	£ s. d. 2 19 10	£ s. d. 2 12 0	£ s. d. 2 13 8
Expenditure per metre driven paid out of wages—				
Dynamite and powder	1 16 8	1 6 2	1 1 0	1 5 0
Smith's costs and loss of steel ...	†5 17 6	6 0	7 9	2 8
Leaving net wage	23 8 6	1 7 8	1 3 3	1 6 0
Other costs per metre driven—				
Attendance and maintenance to machinery	.....	6 10	6 10	6 10
Repairs to machinery	.....	4 0	4 1	4 0
Total of all costs	31 2 8	3 10 8	3 2 11	3 4 6
To this add 10 % for interest and amortization	.....	7 2	7 2	7 2
Also cost of steam power, if water power had not existed	.....	7 4	7 4	2 8
Total	31 2 8	4 5 2	3 17 5	3 14 4
Net wages per man per shift of 8 hours ...	2 0	3 8	3 6	3 9

* Also 38·51 kgs. of powder. † Not deducted from wages.

C. Z. B.

NOTES ON THE SOUTH REWAH GONDWÁNA BASIN.

By Theo. W. H. Hughes. *Records Geol. Survey of India, Vol. XIV., Part* 1, *pp.* 126-138.

A brief description of the geology of the region between the rivers Johilla and Gopat, tributaries of the Son. The rocks examined all belonged to the great Gondwána series, and are reported on group by group under the following heads:—8, Trap; 7, Laméta; 6, Jabalpúr; 5, Maléri; 4, Máhádeva; 3, Rániganj; 2, Barákar (Karhárbári); 1, Tálchir. Except in the last-mentioned and lowest rock-group, where a dip of 5 deg. was observed, the beds throughout the district are practically flat.

In the Barákar group (No. 2) coal was seen, of which a detailed section is given showing it to be unpromising by reason of the many stone-bands separating from each other the several thin layers of coal constituting the seam. Coal is also reported from a few localities in the Rániganj group (No. 3), but in seams too thin to be workable except near Guráru, in the Son River, where a seam at least 5 feet thick was found. An analysis of this coal by Mr. Mallet is given as follows:—

"Moisture	2·7
Volatile (exclusive of moisture)	9·5
Fixed carbon	40·5
Ash	47·3
Total	100·0

"Does not cake. Ash reddish."

Manganese ore, apparently psilomelane, occurs in botryoidal masses in clays of Maléri age (No. 5).

At Úmaria coal is found in the Jabalpúr division (No. 6), the analysis of which gives, as percentages, of fixed carbon 45·8, and of ash 13·5, with 11·3 for moisture, thus resembling a lignite. G. A. L.

NOTES ON THE SOUTH REWAH GONDWÁNA BASIN.

Note II.

By Theo. W. H. Hughes. *Records Geol. Survey of India, Vol. XIV., Part* 4, *pp.* 311–320.

In this second note several additional coal-seams are noticed in the Barákar group (No. 2), viz., in the Sohágpúr coal-field, which stretches into the Korea State at Bichia, a seam more than 5 feet thick, the analysis of the better part of which gives: Moisture 5·8, volatile matter 29·5, fixed carbon 55·0, ash 9·7 (does not cake); in the bed of the Kiwai River near Bélha-Piári a seam about 5 feet 6 inches thick, and of fairly good quality, and another nearly as thick near Bhalmúri; but the finest in the coal-field is a 7 feet 2 inches seam on the banks of the Kulharia-nala, the coal of which does not cake, and yields the following analysis: Moisture 6·7, volatile matter 28·2, fixed carbon 59·6, ash 5·5. G. A. L.

ARTESIAN BORINGS IN INDIA.

By H. B. Medlicott. *Records Geol. Survey of India, Vol. XIV., Part* 3, *pp.* 205–238.

After discussing the *rationale* of artesian wells, and certain new experiments illustrating the matter, the author describes the numerous trials that have been made to adapt such sources of water supply to India, and to discuss the various causes of the failure which has hitherto attended them. The Older and Secondary rock-basins in India are both dismissed as unsuitable for artesian wells, and only one well of the kind is known to the author to have been attempted in rocks older than the Alluvium; this was in Tertiary Rocks, at Gogah (Gogo), in Guzerát, and was unsuccessful. The great alluvial deposits of the plains of India, however, offer a fair prospect of success, although results have so far been disappointing. The special characteristics of all the chief borings which have been put down in the plains of Upper India are given. At Sabzalkot success could not reasonably be expected; at Bhiwáni the ground is presumably out of reach of the northern sources of supply, which are the only hopeful ones. "The Ambála trial is the only one for which success could have been predicted, and as the ultimate condition of that success—to reach the base of the alluvial deposits—has not been accomplished, the prospect remains [in 1881] unaffected, save by the knowledge that the depth of the deposits is greater than might have been expected, or at least hoped for." Sections are given of most borings referred to, including those at Pondicherry—the only successful artesian wells in India—the peculiar circumstances of which are given in detail. G. A. L.

INDEX TO VOL. XXXI.

"Abs." *signifies Abstracts of Foreign Papers at End of the Volume.*

Abstracts of Foreign Papers; Secretary's report, 75.—Abstracts, end of volume.

Academy of Mining; Freiberg, abs. 12.—Pennsylvania, abs. 13.—New York, abs. 13.

ACCIDENTS: Explosions in England, 1851-1878, 8.—From gas in England, 13.—Welsh anthracite coal-field, 184.

Account of a new ventilating fan, by T. J. Bowlker, 93.—Friction of air, 94-101.—Results of experiments, 95-96.—Do. Rockingham fan, 98.—Comparison of fans, 100.—Mode of calculating the friction of air at Byron, 103.—Discussed, 238.

Plate.—12. Bowlker and Watson's ventilator, plan and sections.

Accounts, xii.

Address, G. B. Forster. (See *President's Address.*)

Advertisement, xi.

Aguillon and Pernolet; review of their report on the working of fiery mines in England. (See *Report*, &c.)

Air; compressed-air and hand-power drills, abs. 45.—Compressed air machinery at Skelton Park, 105.—Friction of, 94, 101, 126; abs. 29, 33.

Air-blast; cleaning coal by air, abs. 11.

Air-compressors; Prussia, abs. 28.—Friction, &c., abs. 29.

Allanshaw; pillar working at, 16; and plate 2.

Allenheads; experiments, underground temperature, 66.

Alps; Simplon tunnel, temperature, abs. 44.

Alps (Tauern); gold district of, abs. 38.

Alteration of days of meeting, 31, 49.

Alum works in England, 56.

America; fire-damp explosions. (See *Fire-damp*, &c.)—Bureau of mines and mining, &c., abs. 16.—Pennsylvania. (See *Pennsylvania*).—New York, a summer school of practical mining, abs. 13.—Brazos coal-field, Texas, abs. 39.—Auriferous slate deposits of the Southern Mining region, abs. 39.—Utah, silver sandstone district of, abs. 40.—Maryland, copper deposits of Carroll county, abs. 40.—Colorado, the Whopper lode, Gunnison county, abs. 41.

ANALYSES: Nova Scotia gold, 169.—Newcastle bituminous and American anthracite coal, 177.—Black muck, 225.—Indian coal, abs. 47.—Coal from the South Rewah Gondwána Basin, abs. 47, 48.

Anthracite coal of South Wales, by E. F. Melly, 175.—Definition of anthracite, 175.—History, 176.—Mode of occurrence, analyses, Newcastle bituminous and American anthracite compared, 177.—The anthracite deposit divided into districts, 178.—Quantity of anthracite worked, 179.—Mode of working, 181.—Working by contract, 182.—Cost of working, 183.—Accidents, 184.—Uses of anthracite, 185.—Steam experiments, 188.—Prices, 189.—Coking, 190.—Discussed, 191.—Remarks on smoke, by the Secretary, 191.

Plates.—29. Map of the South Wales anthracite district.—30. Sections at Moreton colliery, near Saundersfoot, and in the Gwendraeth Valley.—31. Workings, single road stall and double road stall.—32. Domestic stove for burning anthracite, and Perkin's furnace.

Anthracite coal-fields of Pennsylvania; new method of mapping, abs. 12.
Apparatus; for breathing in noxious gases, 197.—For cleaning coal by means of air-blast, abs. 11.
Artesian borings in India, abs. 48.
Associate members, xxxiii.

Balloting list, lix.
Barometer readings, 249.
Barometric variations; influence of on ventilation, 25.
BEANLANDS, A.; quotation from his paper On surveying, 35.
Belgium; explosions in, abs. 7.—Hainaut coal-fields, statistics, abs. 4.—Lower coal-measures of, abs. 43.
BEWICK, T. J.; paper On diamond rock boring discussed, 40.
BIRD, W. J.; On coverings for steam pipes. (See *Comparative efficiency of*, &c.)
Boldon; experiments, underground temperature, 66.
Boring; discussion as to direction of dip of strata, 45.
Borings (artesian) in India, abs. 48.
BOWLKER, T. J., ventilating fan. (See *Account of*, &c.)
Brazos coal-field, Texas, abs. 39.
Breakage of colliery ropes; French report on, abs. 17.
BUNNING, T. W., On Fleuss' apparatus, 197.
Bye-laws, xlvii.
Byron colliery; ventilating fan at. (See *Account of*, &c.)

Canada; gold-bearing mispickel veins of Marmora, Ontario, abs. 41.
CANDLER, THOMAS E., On surveying with the loose needle among rails, &c. (See *Description of*, &c.)
Celynen; air-crossings at, 15, and plate 1.—Workings at, 9, and plate 9.
Charter; copy of, xli.
Cleaning Coal. (See *Dry, or wind, method of.*)
Cleveland; meeting at, 1, 105.
Coal; analysis of Indian, abs. 47.—Gases produced by the combustion of, 191.
Coal-cleaning. (See *Dry, or wind, method of.*)
Coal-cleaning by an air-blast, abs. 11.
Coal-dust; an element of danger in mining, abs. 7.—French report, 27.—Use of salt for laying, 145.—W. Galloway on, 147.—John Pattinson on, 149.—French Commission on, abs. 14.
Coal duty; report of a Committee of the Chamber of Deputies on, abs. 15.
Coal-measures (lower) of Belgium, abs. 43.
Coal working in England; French report on, 5.
Colliery rules; French Commission, abs. 14.—Loire coal trade, abs. 15.—North of France Committee, abs. 15.
Colorado; whopper lode, Gunnison county, abs. 41.
Comparative efficiency of non-conducting coverings for steam-pipes, by W. J. Bird, 77.—Various materials described and compared, 77.—Tables showing results of experiments, 78-81.—Discussed, 83.
Compass; fixing needle, 45.
Compressed-air and hand-power drills, abs. 45.
Compressed-air machinery at Skelton Park, 105.
Contents of volume, v.
Copper deposits of Carroll county, Maryland, abs. 40.
Council report, vii.
Coverings for steam-pipes. See *Comparative efficiency of*, &c.)

Darcy's Table for iron pipes, abs. 30.
Description of a method of surveying with the loose needle among rails and other ferruginous substances, by Thomas E. Candler, 33. — Compared with other methods, 34. — Quotations from Mr.

Beanland's paper, 35.—Specimen pages of books, 37.—Formulæ for finding bearings, distances, &c., 39.

Woodcut.—Showing the geometrical principle by which the measurements are obtained, 40.

Diamond rock-boring; Mr. T. J. Bewick's paper discussed, 40.

Drilling; cost of machine compared with hand drilling, abs. 24.

Drilling machines; Walker's, 108.—Improvements in (Prussia), abs. 26.

Drills; power, effect, cost, and wages earned by driving with hydraulic compressed-air and hand-power drills, abs. 45.

Dry, or wind, method of cleaning coal, by E. P. Rathbone, 245.—The system described, 245.—Conditions for satisfactory working, Advantages of the dry over the wet methods, 247.

Plates.—51. Arrangement of blower and hopper.—52, 54. Elevational sections of apparatus—53. Plan of ditto.

DUNN, J. T., gases produced by the combustion of coal, 191.

Dust. (See *Coal-dust.*)

Dynamite used at Lumpsey, 112.

Election of members, 8, 31, 50, 76, 121, 173, 209.

Electric gin, Péronnière Colliery, abs. 10.

Electric safety-lamp: Swan's, 117, and plate, 21.

Electricity; transmission of power by, abs. 9.

Eppleton; ventilation at, 25.—Workings at, 16, and plate, 4.

EXPERIMENTS: Underground temperature, 60, 63, 66.—Coverings for steam pipes, 77.—Ventilating fans, 94.—Do. in Germany, abs. 9.—Fan at Rockingham, 98.—Anthracite coal, 188.—Cleaning coal by an air-blast, abs. 11.—Winding ropes, abs. 21.—Air-compressors, abs. 29.—Drills, abs. 47.

Explosions. (See also *Fire-damp.*)—Albion Mines, Nova Scotia, abs. 7.—Prevention of, abs. 7.—Belgium, abs. 8.—Velocity of propagation of, abs. 8.—Prussian Royal Commission on, abs. 13.

Explosives; improvements in (Prussia), 27.

Fans; Bowlker. (See *Account of*, &c.)—Pelzer, abs. 9.

Finance Committee's report, ix.

Fire-damp; explosions in the anthracite coal mines of Pennsylvania, Abstract of Dr. Chance's analysis of, by Prof. Merivale, 87.—Tabular statements of explosions in the various months, 87, 88.—Explosions in Belgium, 89.—Discussed, 90.—French Commission on, abs. 14.

Fleuss apparatus for breathing in noxious gases, by T. W. Bunning, 197.—Apparatus and lamp described, 197.—Mode of providing oxygen, 201.—Discussed, 202.—Remarks by S. H. Hedley, 202.

Plates.—33, 34, 35. Sketches showing the different portions of the apparatus.—36. Section of the lamp.

Foreign papers, abstracts of; Secretary's report, 75.—Abstracts, end of vol.

Formation of gold nuggets and placer deposits, abs. 42.

Forms, liv.

FORSTER, G. B., Address. (See *President's Address.*)

France: Rive-de-Gier coal-field statistics, abs. 2.—Fire-damp commission, abs. 14.—Loire Committee, report of, rules for fiery mines, abs. 15.—North of France Committee, report of, rules for fiery mines, abs. 15.—Blanzy mines, transmission of power by electricity, abs. 9.—Péronnière colliery, electric gin at, abs. 10.—Committee of the Chamber of Deputies on the coal duty, abs. 15.—Breakage of ropes, report on, abs. 17.—Mineral statistics, 1879, abs. 34.

Freiberg, Royal Mining Academy of, abs. 12.

French Commission on fire-damp, abs. 14.
Furness, hæmatite deposits of. (See *Hæmatite.*)

GALLOWAY, W., On coal dust, 147.
Gas; outbursts of, 9.
Gases; apparatus for breathing in noxious, 197.—Produced by the combustion of coal, 191.
General statement of accounts, xvi.
Geology of the Isthmus of Panama Canal, abs. 42.
GILPIN, EDWIN, On the gold-fields of Nova Scotia. (See *Gold-fields.*)
Gold; Auriferous slate deposits of the Southern mining region (America), abs. 39.—Whopper lode, Gunnison county, Colorado, abs. 41.
Gold-bearing mispickel veins of Marmora, Ontario, abs. 41.
Gold district of the Tauern Alps, abs. 38.
Gold-fields of Nova Scotia, by Edwin Gilpin, 151.—Extent and area of the district, Description of the granite rocks, 153.—Age of the gold-bearing rocks,155.—Alluvial gold,161.—Mining, 163.—Milling, 165.—Cost of crushing, 166.—Assays, 167, 170. — Analyses of gold, 169.—Yield, and average earnings of workmen, 1862 to 1881, 171.—Ditto for the year 1881, 172.

Plates.—22. Sketch map of the Nova Scotia gold-fields.—23. The Waverley gold district.—24. Sketch of corrugated lode, Moose river.—25. Sketch of "Angling" lodes, Oldham.—26. Section of "Bull" vein and "Belt" lode. —27. Plan of "Belt" lode, Montagu. —28. Ten-stamp mill, 750 lbs.

Gold nuggets and placer deposits; formation of, abs. 42.
Graphite deposits; Pennsylvania, abs. 43.
Greasing of pit tubs, abs. 37.
Guibal fan at Rockingham, 93.

Hainaut coal-field; statistics, abs. 4.
Haswell; ventilation at, 16, and plate 3.
Haulage by endless rope, 110.
Hæmatite ore; specimen exhibited, 47.
Hæmatite deposits of Furness, by J. D. Kendall, 211.—Introductory, 211.—Geological structure of the district, 212.—Section of borehole between Dunnerholm and Ireleth, 213.—Do. at Windhills, 215.—Do. at Crossgates, 216.—Form, position, and inner nature of the deposits, 219.—Analysis of black muck, 225.—Puddling ore, its composition, 227.—Soft dark ore, its composition, 228.—Age of the deposits, 229.—Origin of the deposits, 230.—Discussed, 237.

Plates.—37. Map showing the relations of the different geological formations in the district described.—38. Map showing the superficial extent of the various rocks found in the district described.—39. Section showing the comparative depth and the succession of the rocks described.—40. Sections of district shown on plate 38. —41. Cavern at Stainton.—42. Sections of Carboniferous Limestone.—43. Lindal Moor Mines.—44. Stank Mines, Yarlside Mines.—45. Tytup Mines.—46. Park Mines.—47. Askam Mines.—48. Various sections showing formations of deposits.—49. Piece of ore, magnified.—50. Form and mode of occurrence of small loughs.

HEDLEY, S. H., Remarks on Fleuss' apparatus, 202.
Honorary members, xviii.

India; Notes on the South Rewah Gondwána Basin, abs. 47, 48.—Artesian borings in, abs. 48.

Jet mining, by Charles Parkin, 51.—Jet mines subject to the Mines Act; Geological description, 51.—Mode of working, 52.—Means of ventilation, timbering and blasting, Royalty charges, yearly production, and commercial

value, 53.—Locality of mines, manufacture, 54.—Combination of enamel and jet, 55.—Alum works, 56.—Discussed, 57, 205.

KENDALL, J. D., On the hæmatite deposits of Furness. (See *Hæmatite deposits.*)

Lamps. (See *Safety-lamps.*)
Langley Barony lead mines, visit to, 207.
LEBOUR, Professor; On jet, 57.—On underground temperature, 59.—His paper On the mineral resources of the country between Rothbury and Wooler discussed, 203.—His paper On the present state of our knowledge of underground temperature discussed, 204.
Life members, xviii.
Life-saving apparatus; French Commission on, abs. 14.—Fleuss', 197.
Llwynpia; air crossings at, 15, and plate 1.
London smoke nuisance, 191.
Long-wall working; French report on, 5.
Lumpsey; sinking operations at, 1. (See also *Remarks on*, &c.)
Lundhill; coal working at, 17, and plates 3, 6.

Meetings; alteration of, 31, 49.
MELLY, E. F., On the anthracite coal of South Wales. (See *Anthracite coal.*)
MEMBERS, Honorary, xviii.—Life, xviii.—Original, xx.—Ordinary, xxxiii.—Associate, xxxiii.—Students, xxxv.
MERIVALE, Professor; fire-damp explosions in Pennsylvania. (See *Fire-damp*, &c.)
Mineral resources of the country between Rothbury and Wooler; Professor Lebour's paper discussed, 203.
Mineral resources of Persia, abs. 39.
Mineral statistics; France, 1879, abs. 34.—Saxony, 1879, abs. 2.—1880, abs. 36.
Mining Academy; Freiberg, abs. 12.—New York, abs. 13.—Pennsylvania, abs. 13.
Mining industry of Prussia, 1880, abs. 1.
Mining machinery in Prussia; improvements in, abs. 26.
Mountains; temperature in the interior of, abs. 44.

Nomination of members; forms for, liv.
Nova Scotia; gold-fields of. (See *Gold-fields.*)—Explosion at the Albion Mines, abs. 7.

Officers, xix.
Ordinary members, xxxiii.
Ore deposits of Kitzbühel, in Tyrol, abs. 37.
Original members, xx.
Oxygen; mode of providing for Fleuss' lamp, 201.

Panama Canal; Geology of, abs. 42.
PARKIN, CHARLES; On jet mining, 51, 205.
Patrons, xvii.
PATTINSON, JOHN; On coal dust, 149.
Pendlebury; coal working at, 17, and plate 5.
Pennsylvania; fire-damp explosions in. (See *Fire-damp*, &c.)—New method of mapping the anthracite coal-fields of, abs. 12.—Industrial school for miners and mechanics, abs. 13.—Relations of the graphite deposits of Chester County to the geology of the rocks containing them, abs. 43.
Pernolet and Aguillon; Review of their report on the working of fiery mines in England. (See *Report*, &c.)
Persia; mineral resources of, abs. 39.
Pillar and stall working; French report on, 5.
Pipes; Darcy's Table for, 30.
Placer deposits and gold nuggets; formation of, abs. 42.
President's address (G. B. Forster), 123.—Accidents in mines, 123.—Ventilation, 124.—Safety lamps, 126.—Testing lamps, coal dust, 127.—Use of salt for laying dust, fire-damp, 128.—Pressure of gas, colliery warnings, 129.—Gun-

powder, blown-out shots, 130.—Lime cartridges, number of shafts, working large areas of coal, 131, 132.—Fleuss' life-saving apparatus, 133.—Minor accidents, ambulance, 134.—Electric lighting, &c., 134.—Scientific training for mining engineers, 136.—Methods of working coal, 137.—Sinking, 138.—Winding machinery, 139.—Boilers and coke ovens, compressed air, safety hooks, &c., 140.—Underground haulage, coal-cutting machines, drilling, &c., 141.—Conclusion, 142.

PRUSSIA: Mining industry of, 1880, abs. 1.—Royal Commission on explosions in mines, abs. 13.—Mining machinery, &c., improvements in, 1880, abs. 26.—Saarbruck coal-field, abs. 36.

Puddling ore; composition of, 227.

Pumping (Prussia), abs. 27.

Rail guides, steel, (France), abs. 28.

Railway, wire-rope, (Prussia), abs. 27.

RATHBONE, E. P., On the dry, or wind, method of cleaning coal. (See *Dry, or wind, method.*)

Remarks on the points of interest at the Skelton Park and Lumpsey Mines, by A. L. Steavenson, 105.—Compressed air machinery, 105.—Error in using high pressure, 106.—Mechanical drilling, 107.—Walker's drilling machine described, 108.—Haulage by endless rope, 110.—Lumpsey shafts, difficulties encountered in sinking, description of tubbing and cribbing, 111.—Use of dynamite, 112.—Strata at Lumpsey, 113.

Plates.—13. Walker's drilling machine.—14. Endless rope haulage attaching arrangement.—15. Do. detaching hook.—16. Single and double cribs.—17. Tubbing.—18. General arrangement of sinking machinery at the surface.—19. Mode of hanging the sets.—20. Mode in which the pumps and cisterns are supported by the tubbing.

Report of Council, vii.

Report of Finance Committee, ix.

Report on the working and regulation of fiery mines in England, by Messrs. Pernolet and Aguillon: Reviewed by A. L. Steavenson. Introduction, 5.—Accidents, 8.—Exceptional outbursts of gas, 9.—Sudden outbursts from the thill, 10.—Eruption of gas from old workings, 12.—Accidents from gas in England, 13.—Management and working, extension of underground works, 14.—Interior arrangements, methods of working, 15.—Ventilation of the broken, separation of broken districts, mode of setting out the face, 16.—Ventilation of long-wall in course of working, 17.—Ventilation of single or double stall, 18.—The long-wall system, general description, 19.—Working the thick coal in South Staffordshire, general remarks on the methods of working in England, 20.—Ventilation and ventilating appliances, 23.—Volumes of air in mines, 24.—Subdivision of air, division of air at Eppleton, distribution of air, influence of barometric variation, 25.—Working arrangements and superintendence, underground lighting, work with powder, 26.—Dust, 27.—Discussed, 27.

Plates.—1. Air crossings at Llwynpia and Celynen.—2. Broken workings at Ryhope and Allanshaw.—3. Broken workings at Haswell, mode of working the broken at Lundhill.—4. Broken workings of panel at Eppleton.—5. Mode of working the broken in the Doe Mine seam, and in the Rams Mine seam, Pendlebury.—6. Arrangement of the broken workings at Lundhill, and mode of setting out the works in the pillar and single-stall system, Wales.—7. Do. in the wicket system of North Wales.—8. Do. in the pillar and double-stall system in Wales.—9. Arrangement of the broken in the double-stall workings in the Black Vein seam at Celynen, arrangement

of the workings in the Black Vein seam at Celynen.—10. Arrangement of long-wall, working outwards and home.—11. Arrangement of the working faces in the Silkstone seam at Rockingham.
Rive-de-Gier coal-field statistics; abs. 2.
Rockingham; coal workings at, 19, and plate 9.—Guibal fans at, 93, 98.
Ropes; French report on the breakage of abs. 17.—Testing by hydraulic power, abs. 20.—Winding, abs. 21.
Royal charter, xli.
Royal Commission on explosives in Mines (Prussia), abs. 13.
Royal Mining Academy of Freiberg, abs. 12.
Rules, xlvii.
Rules for collieries; French Commission, abs. 14.
Rules for fiery mines; Loire coal trade, abs. 15.—North of France Committee, abs. 15.
Ryhope; broken workings at, plate 2.

Saarbrück coal-field, abs. 36.
Safety-lamps; Swan's electric lamp, 117, and plate 21.—Tin-can lamp, 127.—Fleuss', 133, 201.—French Commission on, abs. 14.
Salt for laying dust in mines, 145.
Saxony; mineral statistics of, 1879, abs. 2, 1880, abs. 36.—Royal Mining Academy of Freiberg, abs. 13.
Schools, Mining. (See *Academy*.)
Scrutineers appointed, 209.
SECTIONS: Strata at Lumpsey, 113.—Section in ascending order from the axis of the anticlinal, Mount Uniacke gold-field, 154.—Borehole between Dunnerholm and Ireleth, 213.—Borehole at Windhills, 215.—Borehole at Crossgates, 216.—"Bull" and "Belt" lode, Nova Scotia, plate, 26—Comparative depth and succession of rocks, Furness district, plate 39.
Silver sandstone district of Utah, abs. 40.
Simplon Tunnel; temperature, abs. 44.
Sinking at Lumpsey, 1, 111.
Skelton Park Mines; meeting at, 1. (See also *Remarks on*, &c.)
Smoke statistics, 191.
Soft dark ore; its composition, 228.
South Hetton; experiments, underground temperature, 63.
South Rewah Gondwána Basin; Notes on, 47, 48.
South Staffordshire; working the thick coal, 5.
STATISTICS:—France, mineral, 1879, abs. 34.—Hainaut coal-field, abs. 4.—Prussia, Mining industry of, 1880, abs. 1.—Rive-de-Gier coal-field, abs. 2.—Saxony, mineral statistics, 1879, abs. 2; 1880, abs. 36.
Steam pipes; coverings for. (See *Comparative efficiency of*, &c.)
STEAVENSON, A. L.; Review of Messrs. Pernolet and Aguillon's report on the working fiery mines in England, 5.—Description of machinery, &c., at Skelton Park and Lumpsey, 105.
STEVENSON, ROBERT; On the use of salt for laying dust in mines, 145.
Strata; discussion as to dip of, in boring, 45.
Students, xxxv.
Subscribing collieries, xxxix.
Subscriptions, xii.
Surveying with the loose needle. (See *Description of*, &c.)
Swan's electric safety lamp, 117, and plate 21.

Table for iron pipes (Darcy's), abs. 30.
Temperature in the interior of mountains, abs. 44.
Temperature underground. (See *Underground temperature*, &c.)
Treasurer's accounts, xii.
Tubbing at Lumpsey, 111.
Tubs; greasing of, abs. 37.
Tyrol ore deposits of Kitzbühel, abs. 37.

Underground temperature in connection with the Simplon Tunnel in the Alps, abs. 44.

Underground temperature, On the present state of our knowledge of, with special reference to the nature of the experiments still required in order to improve that knowledge, by Prof. G. A. Lebour, 59.—British Association Committee, 61.—Opinions of eminent men quoted, 62–66.—Difficulties encountered in making experiments.—Experiments at South Hetton, 63.—Boring at Sperenberg, 64.—Experiments at Boldon and Allenheads, 66.—Method of lowering and raising thermometer, 68.—Tables showing results of experiments, 60, 63, 65, 68.—Discussed, 204.

Use of salt for laying dust in mines, by Robert Stevenson, 145.

Utah; silver sandstone district of, abs. 40.

Ventilating fan, Bowlker's. (See *Account of*, &c.)—Pelzer's, abs. 9.

Ventilating instruments, abs. 7.

Ventilation of mines; French Commission, abs. 14.

Ventilation of mines in England; French report on, 5.—Jet mines, 53.

Ventilation; cost of separate, abs. 31.

Ventilators (Prussia), abs. 28.

Wales; coal working in, 17, and plates, 6, 7, 8.

Walker's drilling machine, 108.

Wind method of cleaning coal. (See *Dry, or wind, method.*)

Winding ropes, abs. 21.

Wire-rope railway (Prussia), abs. 27.

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